FINAL REPORT

Impact Evaluation of PY2015 Rhode Island Commercial and Industrial Upstream Lighting Initiative

National Grid

Date: September 5th, 2018

Table of contents

List of figures

List of tables

1 EXECUTIVE SUMMARY

This Executive Summary provides a high-level review of the findings of the Impact Evaluation of the 2015 program year of the Rhode Island Commercial and Industrial (C&I) Upstream Lighting Program, conducted by the DNV GL team for National Grid. In this section, we state the study objectives, summarize the evaluation approach, and present key findings, conclusions, and recommendations.

1.1 Overview of objectives and approach

The primary goal of this impact evaluation is to quantify the electric energy savings and demand reduction attributable to the Rhode Island C&I Upstream Lighting Program. This enables National Grid to assess whether the program is achieving the expected savings, and to identify any recommendations for improvement.

This study's research objectives include updating the following assumptions with Rhode Island-specific research:

- In-service-rate (ISR) of purchased lamps by facility
- Hours of use (HOU) of purchased lamps—to inform both retrospective and prospective application
- Baseline replaced lamps for estimating delta watts—to inform both retrospective and prospective application
- Gross savings realization rates (RR) to apply prospectively
- Estimates of summer and winter on-peak coincidence factors
- Estimates of HVAC interactive effects
- Percent energy on-peak savings
- Non-electric HVAC interactive effect

This study provides results at a combined RI and MA National Grid territory-level using metered data collected from each site. Chapter 3 shows key results we developed and describes National Grid application of results from this study. Table **1**-**1** shows the final RRs and evaluated savings factors for the initiative.

1.2 Summary of approach

The DNV GL team's approach and methodology were consistent with the procedures and protocols developed during the previous MA upstream lighting impact evaluation conducted in 2012.[1] This study required onsite visits and metering of lighting HOU for a randomly selected sample of measures[2] in locations for which bulbs or kits were purchased through the Upstream Lighting initiative.

Data collection and analysis. Data collection for this impact evaluation included a physical inspection and inventory, interviews with facility personnel, observation of site operating conditions and equipment, and short-term metering of lighting HOU. DNV GL divided the lighting product population into 5 categories as listed below.

Category 1: TLEDs
Category 2: Stairwell Kits

---

1 *Impact Evaluation of the Massachusetts Upstream Lighting Program*, Final Report; prepared by KEMA, Inc. for Massachusetts Energy Efficiency Program Administrators and Massachusetts Energy Efficiency Advisory Council; February 19, 2014. http://ma-eeac.org/wordpress/wp-content/uploads/Upstream-Lighting-Impact-Evaluation-Final-Report.pdf
2 The 2012 evaluation used a randomly selected sample of locations. The 2015 evaluation was based on a randomly selected sample of measures; more detail is provided in section 3.2.

Category 3: Retrofit Kits
Category 4: A-lines and Decoratives
Category 5: G24s

1.3 Summary of findings

Table 1-1 shows the initiative's final RRs and their evaluation precisions by key product category. Recommendations for application of results are provided in section 1.5. For measure categories 2, 3, and 4, RRs were notably low with high precisions. While category 1 had a high RR, this was driven in large part by a delta watt savings tracking estimate that ended up being too low. For category 5, the high RR was driven by the observed HOU being higher than the assumed HOU.

Table 1-1. Final RRs for the initiative by key product category (with in-storage adjustment)[3]

Territory	Category	Accounts	Tracking Energy Savings	Error Ratio		Design Sample Size	Achieved Sample Size	Anticipated	Achieved	Achieved
			kWh	Design	Achieved	n	ń	RP@ 90% CI	RP@ 90% CI	RR
MA+RI	1	490	2,433,119	0.50	0.87	14	13	±29.7%	±23.5%	185%
	2	282	4,440,667	0.50	1.51	10	10	±29.8%	±75.0%	31%
	3	7,062	40,617,342	0.70	0.97	31	30	±23.3%	±28.5%	51%
	4	3,436	43,010,395	0.70	1.21	33	37	±23.1%	±36.4%	45%
	5	408	5,248,218	0.60	0.76	9	12	±41.5%	±43.3%	130%
	345	10,906	88,875,955	-	1.11	73	79	-	±30.1%	60%
MA	1	321	1,218,657	0.50	0.96	11	10	±24.9%	±30.4%	198%
	2	168	2,487,523	0.50	1.00	5	5	±42.8%	±60.4%	8%
	3	4,963	29,291,286	0.70	1.03	21	20	±27.4%	±35.2%	48%
	4	2,413	30,176,566	0.70	1.25	27	31	±23.3%	±38.4%	34%
	5	266	3,424,039	0.60	0.78	4	7	±56.9%	±55.0%	120%
	345	7,642	62,891,890	-	1.15	52	58	-	±34.0%	50%
RI	1	169	1,214,462	0.50	0.34	3	3	±54.1%	±31.2%	163%
	2	114	1,953,144	0.50	0.48	5	5	±40.3%	±34.9%	83%
	3	2,099	11,326,056	0.70	0.85	10	10	±43.9%	±44.9%	61%
	4	1,023	12,833,829	0.70	0.78	6	6	±54.8%	±58.1%	87%
	5	142	1,824,180	0.60	0.73	5	5	±53.5%	±68.7%	152%
	345	3,264	25,984,065	-	1	21	21	-	±49.0%	104%

Table **1**-**1** shows both actual and designed sample size. In MA, the sample was designed at state-level (not at PA level), so whenever there was a primary site refusal, the next prioritized sample site selected may or may not be of the same PA (in this case may or may not be a National Grid site). This changed the final sample size in MA and hence MA+RI sample size. Note the increase in sample size for Categories 4 and 5, while a decrease in sample size for categories 1 and 2. The evaluation results were calculated by post-stratifying the final/achieved sample.

Table 1-2 shows the in-service rates (ISRs) for all measure categories. We found these rates to be low for all categories except category 1, TLEDs, which means that site auditors did not find a significant quantity of the incentivized products in service. Despite these low ISRs, all categories saw some savings (though much lower than anticipated), and categories 1 and 5 still saw substantial savings. Low in-service rates were the result of various factors including products being stored onsite, customers removing or returning defective

[3] DNV GL calculated in-storage adjustments based on the findings of our P49 revisit study for MA. The P49 study evaluated sites where lamps had been in storage, revisiting them two years later to observe how many of these lamps had been installed in the interim. In this report, the installation rate with in-storage adjustment includes the portion of lamps in storage that we anticipate will ultimately be installed, based on our experience in the P49 study. *Massachusetts Commercial and Industrial Upstream Lighting Program: "In Storage" Lamps Follow-up Study*, Final Report; prepared by DNV GL for Massachusetts Energy Efficiency Program Administrators and Massachusetts Energy Efficiency Advisory Council; March 27, 2015. http://ma-eeac.org/wordpress/wp-content/uploads/CI-Upstream-Lighting-Program-In-Storage-Lamps-Follow-up-Study.pdf

products, products being sent to alternate locations[4], or customers exchanging products for which there was no associated tracking information.

Also, note the higher error bounds calculated for all categories, which means that the sample sizes were too small to produce accurate savings estimates. It's also an indication that the error ratio (see Table **1**-**1**) was higher than what we planned for during sample design stage. A current study in MA is revisiting ISR and it may eventually supplant the ISRs shown in Table 1-2. In RI, we also observed high variance in savings factors (like hours of use (HOU) and Delta kW) as shown in **Table 1-3** which could be causing the higher error bounds overall.

Table 1-2. In-service rates for all measure categories (with in-storage adjustment)

Savings Parameter	Energy - Category 1 TLEDs		Energy - Category 2 Stairwell kits		Energy - Category 3 Retrofit kits		Energy - Category 4 A-lines and Decoratives		Energy - Category 5 G24s		Energy - Category 345 combined	
	RR	RP	RR	RP	RR	RP	RR	RP	RR	RP	RR	RP
MA+RI	83%	±12.7%	70%	±16.9%	66%	±15.1%	65%	±16.1%	67%	±22.3%	66%	±11.7%
MA only	92%	±7.8%	58%	±25.4%	69%	±21.4%	65%	±19.5%	69%	±39.6%	66%	±18.4%
RI only	70%	±34.9%	84%	±25.7%	55%	±34.3%	67%	±51.5%	65%	±31.4%	66%	±22.5%

1.4 Conclusions

As shown in Table **1**-**1**, for three LED categories, the RI C&I Upstream Lighting Initiative is delivering substantially lower savings than claimed by National Grid. Site auditors were unable to locate a large portion of the products claimed in tracking, despite extensive efforts to track down products that were not installed at the locations indicated in the tracking information. The onsite teams observed a complex market that may not always lend itself to a one-to-one correspondence between a distributor sale and a specific installation site. Contractors buy product to install at multiple locations and to have on-hand for future work. Franchisees buy product that is first centrally stored and then deployed to multiple locations within RI. Customers may install a majority of the product, but keep the balance in storerooms.

Data collection done for this study showed large and sweeping discrepancies between the initiative tracking data and what was observed onsite, with the tracking data claiming LED lighting that turned out not to be installed where indicated, for a variety of reasons. Some of them in storage, some discarded and others missing.

RI has significantly higher RR's when compared with MA. This could be due to lower hours of use, lower installation rate and Delta kW in MA (see **Table 1-3**): For example, in Category 2

- very low HOU in MA (26% in MA compared to 96% in RI)
- low installation rate (RR of 58% in MA vs 84% in RI) and
- low Delta kW (51% in MA vs 102% in RI).

Table 1-3: Comparison of Hours of use (HOU) and delta kW between states

Parameter	Category	MA+RI		MA		RI	
		RR	RP	RR	RP	RR	RP
HOU	1	116.6%	±14.2%	125.4%	±24.8%	101.7%	±18.9%
	2	66.6%	±32.5%	26.4%	±34.3%	96.6%	±3.1%

[4] Often within the state or service territory

	3	86.2%	±13.6%	76.7%	±17.6%	128.3%	±31.4%
	4	75.1%	±12.0%	66.2%	±21.5%	95.9%	±16.7%
	5	139.2%	±12.7%	131.6%	±19.7%	154.5%	±21.9%
	345	94.6%	±11.4%	84.4%	±15.3%	128.5%	±24.3%
Delta kW	1	185.4%	±14.7%	168.0%	±9.0%	217.1%	±51.9%
	2	67.1%	±32.4%	51.0%	±43.7%	101.9%	±11.7%
	3	87.6%	±16.4%	89.2%	±18.4%	82.6%	±46.2%
	4	92.9%	±17.2%	82.2%	±16.5%	135.1%	±31.8%
	5	134.8%	±4.8%	130.5%	±17.6%	143.6%	±17.2%
	345	96.3%	±11.7%	91.3%	±13.5%	117.9%	±21.7%

RI has better than expected precisions for category 1 and 2 but worse than expected for categories 3,4 and 5. DNV GL recognizes the variability of RRs between the two states but **Table 1-4** below shows that there is an overlap in the RRs based on the upper and lower bounds each category. DNV GL is currently planning a new study to better understand the effects of evaluation by combining programs from two states.

Table 1-4: Energy realization rates' upper and lower bounds by category for RI and MA

CATEGORY	RI		MA	
	Lower Bound	Upper Bound	Lower Bound	Upper Bound
CATEGORY 1	132%	194%	168%	229%
CATEGORY 2	48%	117%	-53%	68%
CATEGORY 3	16%	106%	13%	84%
CATEGORY 4	29%	145%	-4%	73%
CATEGORY 5	83%	220%	65%	175%

1.5 Recommendations

This section presents recommendations from this study. Recommendations are organized by:

- Prospective application of results (PY2019 and beyond)
- Process-related recommendations
- Future research recommendations

1.5.1 Prospective application of results

For prospective application of results (PY2019 and beyond), we recommend that National Grid replace tracking system factors with evaluated system factors, the proposed new energy savings factors are provided in below in Table 1-5 (calculated at MA+RI level). For each product type, multiply each factor in the table to derive the annual savings per unit (kWh) value for that product type. **Table 1-6** provides the proposed new peak demand savings factors including the summer and winter coincidence factors and HVAC interactive effects factors. These can be multiplied by the ISR and kW-saved-per-unit factors from to produce summer and winter peak demand savings.

By applying results in this way, National Grid would apply ISRs from this study until a new study is commissioned to assess ISR changes in 2018, following initiative changes made through end of 2017. At that time, National Grid would only need to replace the ISR factor in **Table 1-6**.

Table 1-5: Proposed Energy Savings factors (MA+RI)

Product type	Category	ISR	kW Saved per Unit	HOU	HVAC Interactive Effect (kWh)
G24 LED	5	67%	0.0173	5,389	102%
A-line, 40/60w	4	65%	0.0312	2,905	99%
A-line, 75/100w	4	65%	0.0438	2,905	99%
Decoratives	4	65%	0.0196	2,905	99%
LED Retrofit kit, <25W	3	66%	0.0356	3,335	103%
LED Retrofit kit, >25W	3	66%	0.0525	3,335	103%
MR16	3	66%	0.0205	3,335	103%
PAR20	3	66%	0.0261	3,335	103%
PAR30	3	66%	0.0354	3,335	103%
PAR38	3	66%	0.0410	3,335	103%
Stairwell Kit, 2ft w/sensor	2	70%	0.0358	5,831	100%
Stairwell Kit, 4ft w/sensor	2	70%	0.0309	5,831	100%
TLED, 2ft	1	67%	0.0079	4,296	104%
TLED, 4ft	1	83%	0.0158	4,296	104%

Table 1-6. Proposed new peak demand savings factors (MA+RI)

Product type	Category	Summer CF	Winter CF	Summer kW HVAC Interactive Effect	Winter kW HVAC Interactive Effect
G24 LED	5	85%	82%	115%	100%
A-line, 40/60w	4	45%	43%	112%	87%
A-line, 75/100w	4	45%	43%	112%	87%
Decoratives	4	45%	43%	112%	87%
LED Retrofit kit, <25W	3	58%	59%	121%	90%
LED Retrofit kit, >25W	3	58%	59%	121%	90%
MR16	3	58%	59%	121%	90%
PAR20	3	58%	59%	121%	90%
PAR30	3	58%	59%	121%	90%
PAR38	3	58%	59%	121%	90%
Stairwell Kit, 2ft w/sensor	2	66%	68%	112%	100%
Stairwell Kit, 4ft w/sensor	2	66%	68%	112%	100%
TLED, 2ft	1	80%	59%	121%	98%
TLED, 4ft	1	80%	59%	121%	98%

1.5.2 Initiative process recommendations

- In their new address validation process, National Grid's vendor should include a flag for customers that have key account managers (National Grid would need to provide current key account management information to the vendor). This key account management flag could be used by National Grid (the vendor would need to alert National Grid of any customers being entered into the initiative tracking data that also have a key account manager) so that National Grid can compare the purchase details with any other current or planned National Grid initiatives the customer could participate in and direct those customers to the initiative that best fits the customer's needs. This would help close the gap between vendor-driven and key account-driven initiatives in cases where this is warranted.[5]

- National Grid's vendor should record and track any customer follow-up activity relating to initiative products in the new inspection tracking system. Vendors should actively check in with National Grid to confirm any direct contact National Grid has had with a customer and any changes to product sales based on that activity are reflected in the tracking data. This will help ensure that when National Grid is contacted by a customer directly and works with that customer to return or exchange any products received through the initiative, this activity gets tracked and saved, to be retrievable later. National Grid and its vendors should agree on a process for this type of communication.
- Vendors should add data validation to tracking data entries so that returns (negative entries) cannot be entered without linking sales to support the return. Initiative tracking data associated with a site can include a negative sales quantity which is typically from customer lamp returns. A negative sales quantity can also be a correction made to the tracking database if the third-party QC contractor could not find the lamps at the site. In order to more easily verify lamp returns made by customers and to avoid possible keying errors, negative sales entries should be linked to the sale in the tracking database. National Grid's vendor should record their follow-up on QC contractor results and how those results were reflected in their tracking system.

1.6 Considerations

- Consider providing distributors with training related to reporting practices and procedures, and tie reporting and verification to distributors. Many times, the lamps were not found on site or the customer had a quantity discrepancy. It could be due to the updates made after the installation or after the purchase was made, but not altered in the tracking data.
- In their new address validation process, National Grid might consider including a flag indicating whether a customer has been served by another distributor. One location had multiple orders in different business names, it could be due to the size of that location, or multiple account numbers, multiple addresses or different people could have ordered the lamps. National Grid should consider tracking those businesses by a distinct address fields and auto populate based on validation prompts.
- Consider using full distinct names of the business without any acronyms.
- In addition to linking distributor sales entries to account numbers, consider including distinct address fields to be auto-populated based on validation prompts. It's possible that large customers have separate addresses for billing, product delivery, and installation; the product delivery and installation addresses should be entered accurately by the distributor based on customer or contractor provided information[6]. Consider building in validation logic so that distributors don't have to enter the same address information multiple times for small customers/purchases.
- Consider adding a purchaser category field such as contractor, electrician, or end-use customer to help track performance progress by purchaser type. This can also help the QC vendor identify contractor projects to follow up with.

---

[5] The evaluation team understands that the National Grid has had a rule in place that if above a certain threshold of fixtures are purchased they should be referred to an account manager in order to engage with the customer regarding other upsell and cross-sell opportunities.

[6] The DNV GL team assumes that distributors enter account information provided by the customer and the billing address and customer name auto populate. This type of data entry would keep customer name and addresses standardized within the data with data entry quality potentially varying in other fields to be entered by the distributor. Having at least the customer and account number accurate and consistent allows the PAs to efficiently track customer activity relating to the upstream lighting initiative.

1.7 Future research

- Consider further ISR analysis. The initiative conducts quality control inspections for about 5 percent of the sites to make sure that they can verify onsite the lighting quantities and types claimed in the distributor sales reports. Part of the intention of the QC contractor visits is to establish that the installs are legitimate, and if not, provide a window for reconciliation after which, if not installed, the units would be backed out of the tracking data and appear as negative sales entries in the third-party provided data for the year of the install. National Grid could consider supporting further research into the discrepancy between ISR shown by the QC contractor visits and those found in this evaluation. Interviews with the third-party initiative manager could help to explain potential tracking challenges.
- Conduct a process evaluation after initiative changes are complete to assess areas of improvement due to the changes. The last process evaluation of the MA C&I Upstream Lighting Initiative was conducted as part of the 2012 evaluation. The timing for a process evaluation of the initiative within the next 6 to 8 months is good to inform and assess initiative delivery.
- Consider assessing the quality of the initiative data in 2018 following the rollout of initiative changes.
- Consider identifying purchaser thresholds by account number, distributor, purchaser, and/or customer installation address. The initiative uses a threshold to prompt follow-up; having multiple thresholds can help identify the individual to follow-up with.
- Consider exploring the extent to which customer installation addresses and associated installation fields have more than one distributor selling products to that address. It’s expected that this would be a more problematic issue prior to initiative changes since initiative changes will now include an address validation process as well as require more detailed information be entered around the location for where products are being installed.

2 INTRODUCTION

This report provides a review of the findings of the Impact Evaluation of the 2015 program year of the Rhode Island Commercial and Industrial (C&I) Upstream Lighting Program, conducted by the DNV GL team for National Grid. In this section, we state the study objectives, summarize the evaluation approach, and present key findings, conclusions, and recommendations.

2.1 Background

The Rhode Island C&I Upstream Lighting initiative attempts to increase the market penetration of energy-efficient lighting technologies in C&I buildings through the use of upstream incentives that are used to buy down the cost of these lighting technologies at the lighting distributor level. The initiative began offering upstream incentives for linear fluorescent lighting technologies in August 2011, and for LED lighting technologies in October 2011. In the case of the LED lamp technologies, the upstream incentives took the place of the downstream lamp incentives that National Grid C&I initiatives had previously offered for these technologies.

The lighting distributors who participate in the initiative are obligated to collect sales data on the type and quantity of discounted products sold, as well as the name, location, and contact information of the customers to whom they sold the products. Every month the distributors submit their sales data to National Grid and to a third-party initiative manager (Initiative Manager), who combines the sales data from the various participating distributors and then allocates the energy savings and incentives to National Grid in both MA and RI. The Initiative Manager then issues invoices to each state for that particular month.

The initiative also utilizes an independent third-party quality control (QC) contractor, who conducts onsite quality control inspections at about 5% of the facilities each month to verify the lighting quantities and types claimed in the distributor sales reports. The QC contractor performs inspections on a selection of the largest purchases, and a random selection of purchases from across the National Grid territories and distributors.

2.1.1 Key initiative changes following 2012

The Upstream Lighting Initiative has continued to grow since 2012, and now features a more diverse measure mix. Notably, however, as shown in Table 2-1, the LED product types included in category 3 were largely included in the Year 1 evaluation.

The 2015 initiative largely consisted of LED lighting technologies. It was expected that linear fluorescents would no longer be offered as part of the Upstream Lighting Initiative after 2016; thus, the focus of this evaluation was on LED lighting technologies. LED product descriptions are provided in Table 2-1.

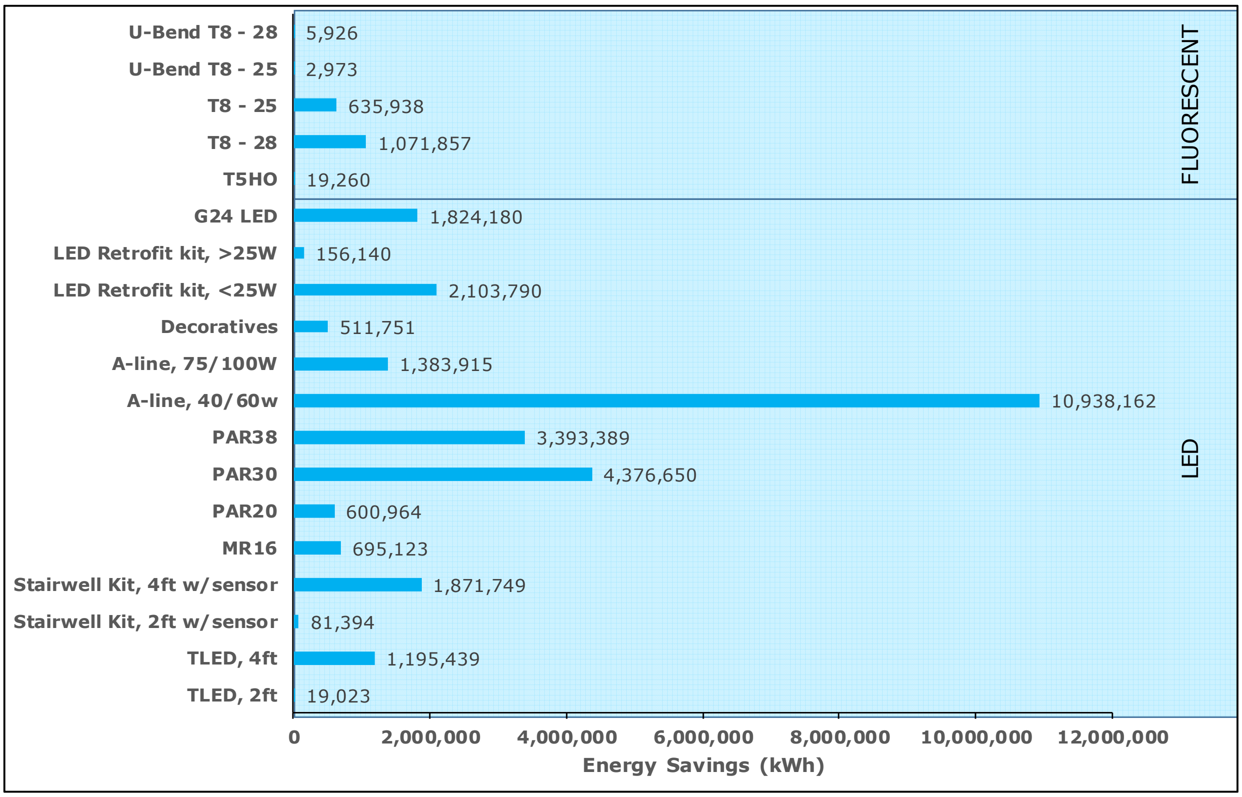
Table 2-1. 2015 Upstream lighting initiative LED product type timing

Sample design category	Product type name	Introduction into initiative/updated
1	TLED, 2ft and 4ft	Jan-15
2	Stairwell Kit w/ sensor, 2ft and 4ft	Jun-14
3	LED retrofit kit, <25W	Apr-13
3	LED retrofit kit, >25W	Apr-13
3	MR16	Oct-11
3	PAR20	Oct-11

3	PAR30	Oct-11
3	PAR38	Oct-11
4	A-line, 40/60w	Jan-15
4	A-line, 75/100w	Jan-15
4	Decoratives	Apr-12
5	G24 LED	Jul-15

Figure 2-1 provides a summary of 2015 upstream lighting tracking savings by product type;

Figure 2-1. Summary of 2015 RI C&I upstream lighting data[7]



National Grid has made (and plans to make further) process improvements in response to ongoing third-party QC results.

Also since the first evaluation, National Grid has made baseline adjustments to account for Energy Independence and Security Act (EISA) legislation through adjustments to measure life. The first impact evaluation showed that a large percentage of incandescent bulbs were being replaced; eventually this trend will not continue, as incandescent bulbs are completely phased out.

7 Savings are based on the final 2015 lighting assumptions spreadsheet provided by the National Grid.

National Grid RI has also updated their HOU assumptions based on the first RI upstream lighting impact evaluation. To the extent possible, this information was leveraged to help determine the error ratios[8] to be used in the sample design for this study. It was expected that since prior evaluation results were directly applied to the savings estimates used by National Grid, the evaluation results would be less variable than they were in the first evaluation, justifying lower error ratios.

2.2 Study objectives

The primary goal of this impact evaluation of the Rhode Island C&I Upstream Lighting program was to quantify the electric energy savings and demand reduction attributable to the program. This will enable the team to assess whether the program is achieving the expected savings as well as identify any recommendations for improvement.

The research objectives of the impact evaluation for the Upstream Lighting program includes updating the following assumptions with Rhode Island-specific research:

- ISR of purchased lamps by facility and space type;
- Hours of use of purchased lamps;
- Baseline replaced lamps for estimating delta watts;
- Gross savings RRs to be applied to 2019 results
- Estimates of summer and winter on-peak coincidence factors.
- Estimates of HVAC Interactive Effects
- Percent Energy On-Peak Savings
- Non-Electric HVAC Interactive Effect

This study provides results for RI using metered data collected from both RI and MA sites. The savings factors were developed so that they may be applied to future program assumption updates.

2.3 Summary of approach

The DNV GL team's approach and methodology were consistent with the procedures and protocols developed during the previous MA upstream lighting impact evaluation conducted in 2012 (2012 evaluation).[9] This study required onsite visits and metering of lighting HOU (hours of use) for a randomly selected sample of measures[10] in locations for which bulbs or kits were purchased through the Upstream Lighting initiative. In addition to onsite metering, our team investigated baseline issues. A high-level synopsis of the evaluation approach is as follows:

---

8 The error ratio is the relative standard error times the square root of the sample size, it's used to see the effects of changing the sample size on the precision of an estimate during sample design development. In this study, to the extent possible we used historical information to inform assumed error ratios. For technologies not covered in the first evaluation, we considered the variability in what the technology could replace to inform the assumed error ratios; when we expected, there would be more variability in what a certain technology could replace we increased the error ratio. We include the observed error ratios as well as the assumed error ratios in this report for comparison.

9 *Impact Evaluation of the Massachusetts Upstream Lighting Program*, Final Report; prepared by KEMA, Inc. for Massachusetts Energy Efficiency Program Administrators and Massachusetts Energy Efficiency Advisory Council; February 19, 2014. http://ma-eeac.org/wordpress/wp-content/uploads/Upstream-Lighting-Impact-Evaluation-Final-Report.pdf

10 The 2012 evaluation used a randomly selected sample of locations. The 2015 evaluation was based on a randomly selected sample of measures; more detail is provided in section 3.2.

Our team investigated RI initiative changes since the 2012 evaluation in MA and determined the customer sample frame to develop a sample design that meets the desired statistical precision targets (MA, RI combined) for key savings parameters such as energy and peak demand savings, as well as other factors such as peak coincidence factors and HVAC interactive effects.

Data collection and analysis. Data collection for this impact evaluation included a physical inspection and inventory, interviews with facility personnel, observation of site operating conditions and equipment, and short-term metering of lighting HOU.

2.4 Methodology

2.4.1 Determining the RI customer sample frame

In September 2016, the DNV GL team received initiative tracking data that covered the period from January 2015 through December 2015. We used these data to determine the sample frame discussed in this subsection. This study thus covers the period from January 2015 through December 2015.

Table 2-2 presents a summary of the 2015 Upstream Lighting Initiative purchases, including quantity and estimated savings. The "Count of Rows" column represents the number of lines in the 2015 tracking data for which each product type appeared. It is roughly equivalent to the number of purchases of each lamp type at a unique site, but not the number of unique sites. It is important to note that the per-lamp savings estimates were drawn from the final 2015 lighting assumptions spreadsheet provided by National Grid, which incorporated the hours of operation determined in the prior evaluation. The DNV GL team applied actual initiative savings to the whole year, rather than applying the total kW and kWh savings estimates provided by the third-party initiative manager.

Table 2-2. Summary of 2015 RI only upstream lighting purchases (Jan-Dec)

Product Type	Count of Rows	Qty of lamps	kWh saved/lamp	Savings (kWh)
A-line, 40/60w	1,332	84,391	129.78	10,938,162
A-line, 75/100W	115	7,591	182.31	1,383,915
Decoratives	236	6,285	81.53	511,751
G24 LED	277	36,906	49.66	1,824,180
LED Retrofit kit, <25W	1,069	13,395	157.35	2,103,790
LED Retrofit kit, >25W	7	673	232.01	156,140
MR16	225	7,676	90.56	695,123
PAR20	377	5,223	115.33	600,964
PAR30	1,074	28,048	156.35	4,376,650
PAR38	1,009	18,737	181.12	3,393,389
Stairwell Kit, 2ft w/sensor	6	174	467.78	81,394
Stairwell Kit, 4ft w/sensor	150	4,645	402.96	1,871,749
TLED, 2ft	15	1,215	15.66	19,023
TLED, 4ft	260	38,131	31.35	1,195,439
Total	**6,152**	**253,090**	**2,293.74**	**29,151,670**

The sample frame for the impact evaluation was defined as unique rows for each customer location and LED product type. The DNV GL team identified several sites where a net negative sales quantity and savings value were being rolled up into standardized[11] customer installation addresses.[12] We performed a manual review of these "net negative savings" sites and were able to rectify some records by locating purchases that should have been rolled into one site. Manually searching the data for different spellings of an address found that, for example, "Rodgers Street" and "Rogers Street" were listed for the same business (based on customer installation name and address), and the team confirmed that the product type description associated with the negative sales quantities matched the product type description for the purchases found.

2.4.2 Combining RI and MA populations

Based on a discussion with National Grid, DNV GL concluded that there is no significant difference in upstream lighting program implementation between the two states (MA and RI). Both states offer the same technologies using the same third-party program manager. Therefore, to be more cost effective, populations of both RI and MA (National Grid only) were combined to create a new population frame (MA+RI). The sample design targets an overall precision of 15%, at the 90% confidence level, based on the MA+RI population. The NGRID results will be evaluated to target the precisions 90/15 at MA+RI level, not at an individual state level. MA NGRID sites used in the MA (P58) sample are incorporated into this new design to be consistent. Using the existing MA sites, sample points were added in RI to achieve the overall targeted precision for the MA+RI population.

2.4.3 Sample design

The DNV GL team developed a sample design that meets the desired statistical precision targets for key savings parameters such as energy and peak demand savings, as well as other factors such as peak coincidence factors and HVAC interactive effects.

Given the initiative growth, planned initiative offerings, and that the initiative now features a more diverse measure mix than it did at the time of the 2012 evaluation, the DNV GL team worked with National Grid to disaggregate the 2015 LED data into specific measure categories for sampling.

Table 2-3 shows the disaggregation for each LED product type.

Table 2-3. Proposed 2015 evaluation measure groups in MA and RI, LEDs only

Product type	Proposed 2015 evaluation sample measure groups	Group Type
G24 LED	5	Reflector
A-line, 40/60w	4	A-series (largely screw-ins)
A-line, 75/100w	4	A-series (largely screw-ins)
Decoratives	4	Decoratives
LED retrofit kit, <25W	3	Recessed downlights
LED retrofit kit, >25W	3	Recessed downlights
MR16	3	Reflector (flood/spot)
PAR20	3	Reflector (flood/spot)
PAR30	3	Reflector (flood/spot)
PAR38	3	Reflector (flood/spot)

11 The MA C&I database team ran the raw Upstream Lighting data through a SAS geocoder in order to standardize installation address (i.e., changing "St." to "Street," etc.).
12 A negative sales quantity can result from customer bulb returns when a purchase was made in a previous year or the third-party QC contractor could not find the bulbs at the site and so they were removed from the tracking database.

Stairwell kit, 2ft w/sensor	2	Stairwell and sensors
Stairwell kit, 4ft w/sensor	2	Stairwell and sensors
TLED, 2ft	1	Linear
TLED, 4ft	1	Linear

Disaggregation of the various measures was based on a product type's similarity to other LED products when reviewing National Grid-supplied assumptions (i.e., delta watts, HOU, measure life, etc.). To the extent possible, the DNV GL team used historical information to inform proposed error ratios.

As Table 2-3 shows, the first evaluation largely informs category groups 3 and 4. Based on the first study, we began with an error ratio of 0.9 for these categories but ratcheted down to an error ratio of 0.7, since the 2012 evaluation showed large uncertainty in HOU, and based on that evaluation, National Grid RI updated the hours component of tracking assumptions. The error ratios used for categories 1, 2 and 5 are informed by the expected variability in what the technology could replace; we expected that there would be more variability in what G24s could replace (category 5) compared to TLEDs (category 1) and stairwell kits with sensors (category 2).

Based on discussions with National Grid, we proceeded with the sample design shown in Table 2-4. The table also shows the relative precision achieved in the evaluation.

Table 2-4. Sample design, Anticipated and Achieved relative precision @ 90% confidence level

Territory	Category	Accounts	Tracking Energy Savings	Error Ratio		Design Sample Size	Achieved Sample Size	Anticipated	Achieved	Achieved
			kWh	Design	Achieved	n	ń	RP@ 90% CI	RP@ 90% CI	RR
MA+RI	1	490	2,433,119	0.50	0.87	14	13	±29.7%	±23.5%	185%
	2	282	4,440,667	0.50	1.51	10	10	±29.8%	±75.0%	31%
	3	7,062	40,617,342	0.70	0.97	31	30	±23.3%	±28.5%	51%
	4	3,436	43,010,395	0.70	1.21	33	37	±23.1%	±36.4%	45%
	5	408	5,248,218	0.60	0.76	9	12	±41.5%	±43.3%	130%
	345	10,906	88,875,955	-	1.11	73	79	-	±30.1%	60%
MA	1	321	1,218,657	0.50	0.96	11	10	±24.9%	±30.4%	198%
	2	168	2,487,523	0.50	1.00	5	5	±42.8%	±60.4%	8%
	3	4,963	29,291,286	0.70	1.03	21	20	±27.4%	±35.2%	48%
	4	2,413	30,176,566	0.70	1.25	27	31	±23.3%	±38.4%	34%
	5	266	3,424,039	0.60	0.78	4	7	±56.9%	±55.0%	120%
	345	7,642	62,891,890	-	1.15	52	58	-	±34.0%	50%
RI	1	169	1,214,462	0.50	0.34	3	3	±54.1%	±31.2%	163%
	2	114	1,953,144	0.50	0.48	5	5	±40.3%	±34.9%	83%
	3	2,099	11,326,056	0.70	0.85	10	10	±43.9%	±44.9%	61%
	4	1,023	12,833,829	0.70	0.78	6	6	±54.8%	±58.1%	87%
	5	142	1,824,180	0.60	0.73	5	5	±53.5%	±68.7%	152%
	345	3,264	25,984,065	-	1	21	21	-	±49.0%	104%

A combined sample size of 24 sites for both TLEDs (14) and stairwell kits (10) with sensors represents an oversampling for both groups; although these groups have relatively low savings in 2015, we expect that they will contribute to higher savings in future program years.

2.5 Data collection and analysis

Data collection for the impact work included physical inspection and inventory, interviews with facility personnel, observation of site operating conditions and equipment, and short-term metering of lighting HOU. Evaluators attempted to determine pre-existing lamps from interviews with facility staff while performing the onsite data collection. Our data collection instrument is included in Appendix B Data collection instrument.

The DNV GL team combined the data gathered during the site visit with the tracking data provided by National Grid to estimate gross savings RRs for annual kWh. We also used the combined data to estimate gross savings results for other relevant savings factors, including HVAC interactive effects, and summer and winter peak coincidence factors. The study also strove to produce new estimates of delta watts and annual HOU that can be applied by National Grid retroactively and going forward. All reporting at this level was sample weighted and statistically representative of the population or appropriate population sub-groups; post-stratification was performed based on our sample design.

Our overall measurement and evaluation plan is detailed below.

2.5.1 Measurement

A key task in the onsite engineering assessment was the installation of measurement equipment to aid in the development of independent savings estimates. The type of measure influences the measurement strategy used.

In the context of an energy analysis, most efficiency measures can be characterized as either time-dependent or load-dependent. Time-dependent equipment typically runs at constant load according to a time-of-day operating schedule. Mathematically, hour-of-day and day-of-week are usually the most relevant variables in the energy savings analysis of these measures. Lighting is the most prevalent time-dependent measure.

2.5.2 Verification

Each site visit included verification of installed equipment, a discussion with facility personnel regarding the baseline characteristics of the measure, and the collection and analysis of monitored data. Once on site, data was collected for calculating savings estimates for all LED products[13] that were purchased through the program; including an inventory of the measures installed. If a measure(s) has been removed, we gathered the reason(s) for removal. If measures were not installed, we asked about timeframe of when they might be installed.[14] The DNV GL team used the revisit study in MA (P49) to inform an estimate of likely future ISR. As National Grid in Rhode Island uses prospective savings from this study for its future planning; for every site that has fixtures in storage, evaluation savings have been adjusted (using in-storage adjustment factor) based on the P49 study results.

Program measure operating characteristics and general building operation characteristics were also gathered, including information on heating and cooling systems to assess interactive effects. Information on the pre-existing or baseline conditions was collected to increase the accuracy of savings calculations. To gather this, the field auditor identified the person who is most knowledgeable about the lighting at each facility and asked questions such as:

- For retrofit, the DNV GL team asked:
    - What type and wattage fixtures were replaced by the program fixtures?
    - Do you have any of these old bulbs/fixtures in storage for us to look at?

[13] This was included for primary sample between LED categories and any backup sample, also between LED categories.
[14] In the first evaluation, measures that were not installed at the time of the visit did not receive any credit for being installed. The revisit study found that some of the bulbs in storage were later installed (within three years of the first site visit) and these additional installations were documented in revised installation rates.

    - Is there a part of your facility that still has similar old bulbs/fixtures in place? [Auditor confirming bulbs/wattage]
    - Is there an untreated space that's like the upgraded space we've looked at together? [Auditor confirming connected wattage (whether more bulbs were installed in upgraded space compared to untreated space)].
- If burnout or new construction, the DNV GL team asked:
    - What type and wattage fixture would you have installed as typical practice?

If the site contact was unable to answer the untreated space question listed above, the field auditor attempted to talk with the contractor or installer to try and understand whether more lamps were installed than were replaced.

- What was the age of the replaced equipment?

2.5.2.1 Quantity discrepancy

Our process for site verification included taking additional steps to attempt to locate incentivized products listed as part of that site's installation in the initiative tracking database. Since we rolled up site installation information on a standardized customer installation address, we expected that customers located at a common address would know about the purchase or at least be able to provide site auditors with additional contact or location information for all purchased associated within that site. For sites where a common address was entered but we found that there were actually multiple businesses associated with the address with multiple addresses, our site auditors attempted to visit each business to verify all lighting products listed as part of the original site were installed or accounted for. Site auditors attempted to speak with the site contact who was most knowledgeable about the lighting project; in some cases, this required site auditors to arrange walk- throughs with contractors to answer auditor questions. Site auditors followed up on products listed in the tracking database with every possible contact who might know about them, visiting multiple locations if necessary.

2.5.3 Monitoring

Time-dependent measures typically call for the installation of time-of-use (TOU) lighting loggers to measure HOU. These small devices use specialized sensors—photocells in the case of lighting measures—to sense and record the dates and times that a device turns on and off. These TOU data were used to support the evaluation in two key ways:

1. To develop peak coincidence factors
2. To develop annual HOU

The measure scope influences the appropriate number of loggers and systems monitored for each site. Factors that drive the number of installed loggers include the number of unique usage areas at the site, expected energy savings for each usage area, and the anticipated level of variation among the schedules within a particular usage area. For this study, most sites included a minimum of 2 months of data collection with an average of 6 loggers/site.

Often occupancy and/or other factors (e.g., daylight) can be the primary variable used to estimate savings, particularly for measures with controls. The DNV GL team monitored and calculated control savings for all stairwell fixtures since that measure includes sensors.

For measures other than stairwell fixtures with sensors, we surmised that the type of technology installed could have prompted the installation of controls. Site auditors sought to monitor controls for which the customer did not receive an incentive, and that were installed after the pre-existing lighting at around the same time as the upstream initiative installation. If a customer received an incentive for controls through the downstream program; we would not attribute credit for controls to the upstream program. Site recruiters asked the following types of questions to inform the type of monitoring equipment to be brought on site.

- Does your facility have any lighting controls?
- Were those lighting controls installed in 2015 or around the time of the initiative fixtures?
- Why were controls added?
- Did you receive an incentive for these controls?

2.5.4 Site analysis

The DNV GL team used data collected from TOU lighting loggers to develop TOU load profiles and estimate total run times during the monitoring period. The typical 2-month data collection period of this study gathers short-term metered data, which can be used to expand to a typical year or to specific periods of interest that do not coincide with the monitoring period (e.g., estimating summer peak demand if the metering is not done in summer). In determining lighting schedules from TOU data, we accommodated annual trends such as seasonal effects (e.g., daylight savings), production, and occupancy swings (such as vacations, business cycles, etc.) to the extent supported by the data. As a general rule, visual inspection of TOU data should reveal explicable patterns that agree with other data sources, such as the information gathered from onsite interviews. Each site visit included an interview with the site contact to gather information that could help in the expansion of short-term metered data.

We compiled the data gathered from the on-sites into spreadsheets for analysis. We calculated the savings as line-by-line comparisons of pre- and post-retrofit electrical use. We developed pre- and post-retrofit energy estimates for each line item within each measure. To calculate RR both tracking and evaluation savings were entered in the analysis spreadsheet. For tracking savings calculation, the pre- portion of the analysis, we used National Grid-provided assumptions for each product type; these assumptions assume an average baseline and installed wattage across a mix of products with varying recorded wattages. And for evaluated savings, pre-retrofit wattage was estimated based on customer interviews. We also calculated interactive cooling and heating effects of the installed measures utilizing engineering algorithms where applicable. This component of the savings is described in further detail in the following section.

We performed all of this to identify discrepancies between the tracked and gross evaluated savings according to each adjustment phase, including technology, quantity, operation, and HVAC interaction which are explained further below.

In addition to these adjustments, the DNV GL team provided measure-specific estimates for the following savings input parameters, based on the data collected on site:

- ISR
- Delta watts
- Annual HOU

2.5.5 HVAC interactive effects

When lighting equipment converts electrical energy to light, most of that energy dissipates in the form of heat. Energy efficient lighting measures convert more electrical energy to light and less to heat. This serves to reduce the heat gain to a given space and accordingly reduce the load on cooling equipment. However, this reduced heat gain has the added consequence of increasing the load on the heating system. A complete estimation of energy savings considers the associated impacts on the space's heating and cooling systems, or the "HVAC interactive effects."

As part of the onsite methodology, evaluators interviewed facility personnel to ascertain the cooling and heating fuel, system type, and other information with which to approximate the efficiency of the HVAC equipment serving the space of each lighting installation. The DNV GL team expressed HVAC system efficiency in dimensionless units of coefficient of performance (COP), which reflects the ratio of work performed by the system, in this case heat removed or added to the work input of the system. Table 2-5 details the COP assumptions for general heating and cooling equipment types expected to be encountered in this study. Where site-specific information yields improved estimates of system efficiency, these were used in place of the general assumptions below.

Table 2-5. General heating and cooling COP assumptions

Cooling system type	COP
Packaged DX	2.9
Window DX	2.7
Chiller <200 ton	4.7
Chiller >200 ton	5.5
Air to air heat pump	3.9
Water to air heat pump	4.4
Refrigerated area (high temp)	1.4
Refrigerated cases (low temp)	1.9

Heating system type	COP/Eff
Air to air heat pump	1.5
Electric resistance	1
Water to air heat pump	2.8
Hot Water Boiler	80%
Condensing Boiler	91%
Steam Boiler	78%
Warm Air Furnace	82%
Condensing Furnace	95%

We calculated HVAC interactive effects at all sites where heating or cooling systems were in use. Leveraging the 8,760 profile of hourly demand impacts, we computed electric interactive effects during the hours that lighting and HVAC are assumed to operate in unison.

The DNV GL team utilized the Typical Meteorological Year 3 (TMY3) hourly dry-bulb temperatures for Providence, Rhode Island as the balance point criteria in this analysis. For each hour in a typical year, we computed HVAC interactive effects according to the following equations:

*Cooling kW Effects = 80% * Lighting kW Savings / Cooling System COP*
*Heating kW Effects = -80% * Lighting kW Savings / Heating System COP*

The 80% values represent the assumed percentage of the lighting energy that translates to heat and stays in the space, which either must be removed from the space by the air conditioning system or added to the space by the heating system during the aforementioned HVAC hours. Also, heating factors are negative because electric heating interaction decreases gross lighting savings, while cooling interactive increases it.

3 FINDINGS

The results presented in the following subsections include statewide-level RRs (and associated precision levels) for annual kWh savings, percent on-peak kWh savings, and on-peak demand (kW) coincidence factors at the times of the winter and summer peaks, as defined by the ISO New England Forward Capacity Market (FCM). All coincident summer and winter peak reductions were calculated using the following FCM definitions:

- **Coincident summer on-peak kW reduction** is the average demand reduction that occurs during all hours between 1 p.m. and 5 p.m. on non-holiday weekdays in June, July, and August.

- **Coincident winter on-peak kW reduction** is the average demand reduction that occurs during all hours between 5 p.m. and 7 p.m. on non-holiday weekdays in December and January.

The adjusted gross energy savings and connected kW demand reduction are presented with their associated RR and relative precision for each lighting measure. These tables also present results as adjustments to tracking savings. Each of these adjustments is described below:

- **Technology adjustment:** This adjustment reflects the change in savings due to the identification of a lighting technology (fixture type and wattage) at the site that is different than the technology represented in the initiative tracking system estimate of savings.
- **Quantity adjustment:** This adjustment reflects the change in savings due to the identification of a quantity of or base or proposed lighting fixtures at the site that is different than presented in the initiative tracking system estimate of savings.
- **Operational adjustment:** This adjustment reflects the change in savings due to the observation or monitoring of lighting operation hours at the site that is different than represented in the tracking system estimate of savings.
- **HVAC interaction adjustment:** This adjustment reflects changes in savings due to interaction between the lighting and HVAC systems among the sampled sites. Generally, these impacts cause a heating penalty and a cooling credit. This adjustment reflects impacts from electric heating and/or cooling, not other fuels.

The report also included the savings factors for summer and winter on-peak coincidence factors, summer and winter kW HVAC interactive effect factors, a kWh HVAC interactive effect factor, the percent of energy savings during on-peak periods, and a non-electric heating HVAC interactive effect, which is presented in MMBtu/kWh saved. Relative precision levels and error bounds are calculated at the 80% and 90% confidence level for demand savings factors and values. For all kWh RRs, the standard 90% confidence level is used.

All results tables in this section include additional savings from lamps found in storage that we believe will move from storage to socket, contributing to savings; each table contains one row including in-storage adjustments and one row excluding them. Note that the sample size listed in the tables below are for actual achieved sample counts (ń), and they are different from the designed sample size ("n" specifically in MA).

3.1 Category 1, TLED findings

This section summarizes the study's findings for category 1: TLEDs, 2-ft and 4-ft.

3.1.1 Results

Table 3-1 presents the category 1 results with the in-storage installation adjustment applied to in-storage sites from this study based on previous study (P49) findings. The RR for category 1 was 185% with HVAC interaction effects and in-storage factor included. Note that the gross tracking savings did not include HVAC interactive effects. The relative precision for this estimate was ±23.5% at the 90% level of confidence. The error ratio was 0.87, which was higher than the estimated error ratio of 0.50. Error ratios in both states show that there was more deviation (from tracking estimates) in MA than in RI results. The results suggest that RI had relatively higher quantity discrepancy compared to MA which lead to a lower RR overall.

Table 3-1. Summary of category 1 energy RR

CAT 1 Savings Parameters	Energy - LED					
	MA+RI (ń= 13)		MA only (ń= 10)		RI Only (ń= 3)	
	kWh	% Gross	kWh	% Gross	kWh	% Gross
Gross savings (Tracking)	2,433,119		1,218,657		1,214,462	
Technology Adjustment	2,100,058	86.3%	828,146	68.0%	1,421,758	117.1%
Quantity Adjustment	-802,538	-33.0%	-166,406	-13.7%	-793,923	-65.4%
Operational Adjustment	619,989	25.5%	477,122	39.2%	31,271	2.6%
HVAC Interactive Adjustment	153,098	6.3%	57,591	4.7%	108,295	8.9%
Adjusted Gross savings	4,503,727	185.1%	2,415,110	198.2%	1,981,862	163.2%
Gross RR	185.1%		198.2%		163.2%	
Relative Precision	±23.5%		±30.4%		±31.2%	
Confidence Interval	90.0%		90.0%		90.0%	
Error Ratio	0.87		0.96		0.34	

Table 3-2 presents the territory wide savings factors resulting from this analysis. The category 1 ISR is approximately 83% with the in-storage[14] installation adjustment with MA having higher installation rate compared to RI. All relative precisions were calculated at the 90% confidence level for energy and at 80% for demand. The summer on-peak coincidence factor was 80.2%, with a relative precision of ±5.7% at the 80% level of confidence. The on-peak winter coincidence factor was 58.6%, with a relative precision of ±3.5% at the 80% level of confidence. The table also provides savings factors for on-peak summer and winter kW HVAC interactive effects, kWh HVAC interactive effect, HOU RR and percent on-peak kWh.

Table 3-2. Summary of category 1 savings factors

Savings Parameter	Category 1					
	MA+RI (ń= 13)		MA only (ń= 10)		RI Only (ń= 3)	
	Value	RP @ 80% CI	Value	RP @ 80% CI	Value	RP @ 80% CI
ISR (Quantity Adjustment - kW)	82.7%	±12.7%	91.9%	±7.8%	69.9%	±34.9%
Delta Watts (Technology Adjustment - kW)	185.4%	±14.7%	168.0%	±9.0%	217.1%	±51.9%
Connected kW RR	153.4%	±10.5%	154.3%	±15.6%	151.7%	±25.0%
Summer Coincidence Factor						
On Peak Hours	80.2%	±5.7%	78.1%	±11.1%	84.1%	±2.9%
Winter Coincidence Factor						
On Peak Hours	58.6%	±3.5%	65.4%	±15.9%	46.2%	±49.4%
Summer kW HVAC Interactive Effect						
On Peak Hours	120.7%	±2.7%	118.8%	±3.6%	124.1%	±6.5%
Winter kW HVAC Interactive Effect						
On Peak Hours	98.2%	±2.3%	97.5%	±4.2%	100.0%	±0.0%
kWh Factors (Precisions at 90% confidence)						
Connected kWh RR	153.3%	±10.6%	154.3%	±15.6%	151.7%	±25.0%
kWh HVAC Interactive Effect	103.5%	±1.3%	102.4%	±2.2%	105.8%	±1.9%
Hours of Use RR	116.6%	±14.2%	125.4%	±24.8%	101.7%	±18.9%
% On Peak kWh	82.2%	±4.3%	80.8%	±7.3%	85.1%	±6.4%
Non-Electric						
Heating HVAC Interaction Effect (MMBtu/kWh)	-0.00078		-0.00031		-0.00157	

3.1.2 Key drivers

The most important finding in category 1 is the adjusted gross savings value of 185%— a misleadingly high value that is driven largely by a very positive technology adjustment number (217.1% in RI). This large technology adjustment number is a result of our frequently finding that 15-watt, 17.5 watt and sometimes 11-watt TLEDs had been installed instead of the assumed 19-watt TLEDs. Since the tracking savings assumed an 8.5-watt delta, this 4-watt difference has a major impact on the delta watt factor. An additional driver, though to a lesser extent, is that for a majority of sites 32-watt lamps were being replaced with TLEDs instead of the assumed 28-watt lamps.

3.1.3 Quantity discrepancies

Site auditors generally found initiative TLEDs to be installed; this LED category had the highest ISR (70% in RI) when compared to the other four LED categories. No lamps were found in storage. Two out of the 3 RI sites had a subset of lamps that were found neither onsite nor in storage. The number of lamp sales included in the tracking data for visited RI sites is included in Table 3-3 along with the number of lamps not found to be installed for various reasons (i.e., in storage, missing, or burnout).

Table 3-3. Quantity discrepancy for category 1 products (RI only, unweighted)

Quantity discrepancy classification	Category 1	% of tracking
Quantity discrepancy *(lamps not installed at time of site visit)*	**298**	**13%**
Confirmed as in-storage, to be installed over time	0	0%
Missing	298	13%
Burned out	0	0%
Tracking sales quantity total (visited sites, n=3)	**2,276**	**100%**

3.2 Category 2, stairwell kit findings

This section summarizes the study's findings for category 2: stairwell kits with sensors, 2-ft and 4-ft.

3.2.1 Results

Table 3-4 presents the category 2 results with the in-storage[14] installation adjustment applied to in-storage measures from this study based on previous study (P49) findings. The RR for category 2 was 31.4% with HVAC interaction effects and in-storage factor included. Note that the gross tracking savings did not include HVAC interactive effects. The relative precision for this estimate was ±75.0% at the 90% level of confidence. The higher precision in this category is due to a very low RR for MA sampled sites (unweighted average of 22% for all 5 sites), it leads to a higher error ratio (1.51) than what was anticipated during sample design (0.50).

In MA, the drastic reduction in savings was due to delta kW adjustment (51%) compared to RI's 101%. Overall (MA+RI) technology adjustment was about -33%. Quantity and operational adjustment factors account for the remaining -35%.

Table 3-4. Summary of category 2 energy RR

CAT 2 Savings Parameters	Energy - LED					
	MA+RI (ń= 10)		MA only (ń= 5)		RI Only (ń= 5)	
	kWh	% Gross	kWh	% Gross	kWh	% Gross
Gross savings (Tracking)	4,440,667		2,487,523		1,953,144	
Technology Adjustment	-1,461,276	-32.90%	-1,219,636	-49.00%	36,233	1.90%
Quantity Adjustment	-887,366	-20.00%	-534,488	-21.50%	-326,957	-16.70%
Operational Adjustment	-699,437	-15.80%	-540,047	-21.70%	-56,683	-2.90%
HVAC Interactive Adjustment	3,882	0.10%		0.00%	5,389	0.30%
Adjusted Gross savings	1,396,470	31.40%	193,352	7.8%	1,611,125	82.50%
Gross RR	31.40%		7.80%		82.50%	
Relative Precision	±75.0%		±60.4%		±34.9%	
Confidence Interval	90.00%		90.00%		90.00%	
Error Ratio	1.51		1.00		0.48	

The category 2 ISR is approximately 70% with the in-storage installation adjustment. Table 3-5 presents the statewide savings factors resulting from this analysis. All relative precisions were calculated at the 90% confidence level for energy and at 80% for demand. The summer on-peak coincidence factor was 66.2%, with a relative precision of ±28.3% at the 80% level of confidence. The on-peak winter coincidence factor was 67.6%, with a relative precision of ±17.9% at the 80% level of confidence. The table also provides savings factors for on-peak summer and winter kW HVAC interactive effects, kWh HVAC interactive effect, HOU RR and percent on-peak kWh.

Table 3-5. Summary of category 2 savings factors

Savings Parameter	Category 2					
	MA+RI (ń= 10)		MA only (ń= 5)		RI Only (ń= 5)	
	Value	RP @ 80% CI	Value	RP @ 80% CI	Value	RP @ 80% CI
ISR (Quantity Adjustment - kW)	70.2%	±16.9%	57.80%	±25.4%	83.60%	±25.7%
Delta Watts (Technology Adjustment - kW)	67.10%	±32.4%	51.00%	±43.7%	101.90%	±11.7%
Connected kW RR	47.10%	±38.0%	29.50%	±68.0%	85.10%	±36.0%
Summer Coincidence Factor						
On Peak Hours	66.20%	±28.3%	33.70%	±37.2%	90.60%	±6.5%
Winter Coincidence Factor						
On Peak Hours	67.60%	±17.9%	27.60%	±34.7%	97.50%	±1.3%
Summer kW HVAC Interactive Effect						
On Peak Hours	112.50%	±7.0%	99.30%	±1.4%	116.20%	±9.4%
Winter kW HVAC Interactive Effect						
On Peak Hours	100.00%	±0.0%	100.00%	±0.0%	100.00%	±0.0%
kWh Factors (Precisions at 90% confidence)						
Connected kWh RR	47.10%	±38.0%	29.50%	±68.0%	85.10%	±36.0%
kWh HVAC Interactive Effect	100.30%	±0.3%	100.00%	±0.0%	100.30%	±0.5%
Hours of Use RR	66.60%	±32.5%	26.40%	±34.3%	96.60%	±3.1%
% On Peak kWh	66.40%	±1.4%	71.50%	±4.8%	65.40%	±0.5%
Non-Electric						
Heating HVAC Interaction Effect (MMBtu/kWh)	-0.00002		0		-0.00005	

3.2.2 Key drivers

The evaluation of the stairwell kits found several factors that led to the overall RR of 31%. The lower than expected ISR of 70% was one of the primary drivers of this finding. The next section discusses this result in more detail.

In addition to the low ISR, the evaluation found a reduction in savings due to differences in the delta watt factor. In order to understand the differences between National Grid estimate and the evaluated delta watt, it is important to know how National Grid estimate was derived. A stairwell fixture purchased through this initiative includes both the linear LED (2- or 4-foot variety) and the integrated bi-level dimming control. The dimming control allows the fixture to step down to a reduced light level when the location is unoccupied. When the sensor picks up activity, the fixture returns to 100% on. The dimmed level is set once at the individual fixture by the user. Generally, these can be set in 10% increments of power, but some varieties allow for finer settings. Once set, the fixture operates at the two levels, full and low-level, depending upon occupancy.

Tracking savings assume the proposed LED fixtures operate at full power 20% of the time and at 3/8 power 80% of the time. This equates to 50% of the proposed lamp full wattage across all 8,760 hours per year.

The 8,760 hours' assumption is based on these being intended for stairwells, which requires 24/7 illumination by code.

The delta watt, or technology adjustment, in the evaluated results represents the difference between the tracking estimates of delta watts (66-watt baseline fixture – 50% full rated watts of proposed fixture) and the evaluation estimate of delta watts (baseline watts – [full rated watts of proposed fixture x [logged % lumen/logged total operating hours]]).

As noted in the methodology section above, the evaluated baseline wattages were established through site contact interview and/or observation of untreated, but similar spaces. In many cases, the evaluated baseline wattages were slightly different than the tracking estimates. Therefore, the delta watt differences were made up of both lower baseline wattages and different installed lamp wattages operating at levels other than 50% across all operating hours.

The third and final discrepancy in this category, the operational adjustment, is also important to understand. This adjustment represents the difference between the tracking savings estimate of 8,760 total operating hours and the evaluation's estimate of total operating hours. The evaluation found that in some cases, the stairwell kits were installed in areas other than stairwells, including hallways, storage, and mechanical rooms. Additionally, these locations as well as some actual stairwells were being controlled by wall switch. This means that the baseline hours of operation were not always 8,760 hours, but something less. The evaluation used the 0% readings from the light level loggers to estimate when the lights would have been off in the pre-condition.

3.2.3 Quantity discrepancies

The quantity reduction is being mostly driven by fixtures not found in-service during the time of the evaluation. The number of lamp sales included in the tracking data for visited sites is included in Table 3-6 along with the number of lamps not found to be installed for various reasons (i.e., in storage, missing, or burnout).

Table 3-6. Quantity discrepancy for category 2 products (RI only, unweighted)

Quantity discrepancy classification	Category 2	% of tracking
Quantity discrepancy *(lamps not installed at time of site visit)*	**32**	**10%**
Confirmed as in-storage, to be installed over time	26	8%
Missing	6	2%
Burned out	0	0%
Tracking sales quantity total (visited sites, n=5)	**332**	**100%**

3.3 Category 3, retrofit kit findings

This section summarizes the study's findings for category 3. Category 3 lights consist of LED point source recessed can retrofit kits, MR16 pin-based (often seen in track lighting), and PAR fixtures screw-in Edison base lamps. Category 3 initiative product type descriptions are also included in Table 2-1 .

3.3.1 Results

Table 3-7 presents the category 3 results with the in-storage[14] installation adjustment applied to in-storage sites from this study based on previous study (P49) findings. The RR for category 3 was 51% with HVAC interaction effects and in-storage factor included. The relative precision for this estimate was ±28.5% at the

90% level of confidence. Note that the gross tracking savings did not include HVAC interactive effects. The error ratio was 0.97, which was higher than the estimated error ratio of 0.70.

Lower RR was primarily due to the quantity discrepancy, specifically in RI about 19% (unweighted) of the tracking fixtures were missing, 11% (unweighted) were in storage.

Table 3-7. **Summary of category 3 energy RR**

CAT 3 Savings Parameters	Energy - LED					
	MA+RI (ń= 30)		MA only (ń= 20)		RI Only (ń= 10)	
	kWh	% Gross	kWh	% Gross	kWh	% Gross
Gross savings (Tracking)	40,617,342		29,291,286		11,326,056	
Technology Adjustment	-5,015,284	-12.3%	-3,173,959	-10.8%	-1,968,478	-17.4%
Quantity Adjustment	-12,088,477	-29.8%	-8,099,117	-27.7%	-4,166,960	-36.8%
Operational Adjustment	-3,250,772	-8.0%	-4,190,222	-14.3%	1,469,486	13.0%
HVAC Interactive Adjustment	586,342	1.4%	339,264	1.2%	271,077	2.4%
Adjusted Gross savings	20,849,151	51.3%	14,167,252	48.4%	6,931,182	61.2%
Gross RR	51.3%		48.4%		61.2%	
Relative Precision	±28.5%		±35.2%		±44.9%	
Confidence Interval	90.0%		90.0%		90.0%	
Error Ratio	0.97		1.03		0.85	

The category 3 ISR is approximately 66% with the in-storage adjustment. Table 3-8 presents the statewide savings factors resulting from this analysis. All relative precisions were calculated at the 90% confidence level for energy and at 80% for demand. The summer on-peak coincidence factor was 57.7%, with a relative precision of ±16.5% at the 80% level of confidence. The on-peak winter coincidence factor was 58.6%, with a relative precision of ±7.0% at the 80% level of confidence. The table also provides savings factors for on-peak summer and winter kW HVAC interactive effects, kWh HVAC interactive effect, HOU RR and percent on-peak kWh.

Table 3-8. **Summary of category 3 savings factors**

Savings Parameter	Category 3					
	MA+RI (ń= 30)		MA only (ń= 20)		RI Only (ń= 10)	
	Value	RP @ 80% CI	Value	RP @ 80% CI	Value	RP @ 80% CI
ISR (Quantity Adjustment - kW)	66.0%	±15.1%	69.0%	±21.4%	55.5%	±34.3%
Delta Watts (Technology Adjustment - kW)	87.6%	±16.4%	89.2%	±18.4%	82.6%	±46.2%
Connected kW RR	57.9%	±19.8%	61.5%	±29.1%	45.8%	±38.4%
Summer Coincidence Factor						
On Peak Hours	57.7%	±16.5%	56.8%	±24.9%	61.5%	±34.7%
Winter Coincidence Factor						
On Peak Hours	58.6%	±7.0%	58.3%	±25.1%	60.0%	±27.8%
Summer kW HVAC Interactive Effect						
On Peak Hours	120.9%	±2.4%	121.7%	±3.7%	117.8%	±1.5%
Winter kW HVAC Interactive Effect						
On Peak Hours	90.0%	±8.3%	89.9%	±12.6%	90.2%	±16.0%
kWh Factors (Precisions at 90% confidence)						
Connected kWh RR	57.9%	±19.8%	61.5%	±29.1%	45.8%	±38.4%
kWh HVAC Interactive Effect	102.9%	±2.4%	102.5%	±4.1%	104.1%	±2.4%
Hours of Use RR	86.2%	±13.6%	76.7%	±17.6%	128.3%	±31.4%
% On Peak kWh	78.5%	±5.6%	83.3%	±8.0%	65.9%	±8.4%
Non-Electric						
Heating HVAC Interaction Effect (MMBtu/kWh)	-0.00048		-0.00045		-0.00059	

3.3.2 Key drivers

The driver for the low adjusted gross savings (51%) in this category was the similarly low in-service rate (66%), which means that site auditors did not find a significant quantity of the products installed. Our onsite visits identified various reasons for this, including kits still in storage, kits reportedly having been thrown away after breaking or proving defective[15], and kits with product issues in the process of getting exchanged through the initiative; further details are covered in the next subsection.

3.3.3 Quantity discrepancies

The quantity reduction is being mostly driven by a combination of missing and fixtures found in storage during the time of the evaluation. The number of lamp sales included in the tracking data for visited sites is included in Table 3-9 along with the number of lamps not found to be installed for various reasons (i.e., in storage, missing, or burnout).

[15] Customer reports of products breaking when trying to install or throwing away because they were considered defective was most prevalent for category 5, G24s. Product issues of flickering caused by ballast incompatibility was related to early generation products no longer offered through the program. It's expected that later generation LED technologies will present less product issues than those found as part of this evaluation.

Table 3-9. Quantity discrepancy for category 3 products (RI only, unweighted)

Quantity discrepancy classification	Category 3	% of tracking
Quantity discrepancy *(lamps not installed at time of site visit)*	**284**	**33.3%**
Confirmed as in-storage, to be installed over time	91	10.7%
Missing	162	19%
Burned out/Discarded	31	3.6%
Tracking sales quantity total (visited sites, n=10)	**854**	**100%**

3.4 Category 4, A-line and decorative findings

This section summarizes the study's findings for category 4: A-lines and Decoratives.

3.4.1 Results

Table 3-10 presents the category 4 results with the in-storage installation adjustment applied to in-storage sites from this study based on previous study (P49) findings. The RR for category 4 was 45% with HVAC interaction effects and in-storage factor included. The relative precision for this estimate was ±36.4% at the 90% level of confidence. Note that the gross tracking savings did not include HVAC interactive effects. The error ratio was 1.21, which was higher than the estimated error ratio of 0.70.

Lower overall RR was primarily driven by lower MA RR. RI only RR was ~87%, where higher Technology adjustment was offset by lower quantity adjustment.

Table 3-10. Summary of category 4 energy RR

CAT 4 Savings Parameters	Energy - LED					
	MA+RI (ń= 37)		MA only (ń= 31)		RI Only (ń=6)	
	kWh	% Gross	kWh	% Gross	kWh	% Gross
Gross savings (Tracking)	43,010,395		30,176,566		12,833,829	
Technology Adjustment	-3,085,422	-7.2%	-5,359,813	-17.8%	4,509,280	35.1%
Quantity Adjustment	-13,891,057	-32.3%	-8,791,196	-29.1%	-5,767,815	-44.9%
Operational Adjustment	-6,491,443	-15.1%	-5,412,028	-17.9%	-479,563	-3.7%
HVAC Interactive Adjustment	-209,412	-0.5%	-255,189	-0.8%	121,506	0.9%
Adjusted Gross savings	19,333,062	44.9%	10,358,341	34.3%	11,217,236	87.4%
Gross RR	44.9%		34.3%		87.4%	
Relative Precision	±36.4%		±38.4%		±58.1%	
Confidence Interval	90.0%		90.0%		90.0%	
Error Ratio	1.21		1.25		0.78	

The category 4 ISR is approximately 65% with the in-storage installation adjustment.

Table 3-11 presents the statewide savings factors resulting from this analysis. All relative precisions were calculated at the 90% confidence level for energy and at 80% for demand. The summer on-peak coincidence factor was 45.2%, with a relative precision of ±18.8% at the 80% level of confidence. The on-peak winter coincidence factor was 42.8%, with a relative precision of ±7.3% at the 80% level of confidence. The table also provides savings factors for on-peak summer and winter kW HVAC interactive effects, kWh HVAC interactive effect, HOU RR and percent on-peak kWh.

Table 3-11. Summary of category 4 savings factors

Savings Parameter	Category 4					
	MA+RI (ń= 37)		MA only (ń= 31)		RI Only (ń=6)	
	Value	RP @ 80% CI	Value	RP @ 80% CI	Value	RP @ 80% CI
ISR (Quantity Adjustment - kW)	65.2%	±16.1%	64.6%	±19.5%	66.7%	±51.5%
Delta Watts (Technology Adjustment - kW)	92.9%	±17.2%	82.2%	±16.5%	135.1%	±31.8%
Connected kW RR	60.6%	±22.6%	53.1%	±28.9%	90.2%	±59.6%
Summer Coincidence Factor						
On Peak Hours	45.2%	±18.8%	39.0%	±20.5%	59.7%	±42.5%
Winter Coincidence Factor						
On Peak Hours	42.8%	±7.3%	41.5%	±30.7%	46.1%	±24.4%
Summer kW HVAC Interactive Effect						
On Peak Hours	112.2%	±4.5%	118.9%	±3.4%	102.0%	±3.1%
Winter kW HVAC Interactive Effect						
On Peak Hours	86.6%	±13.0%	80.2%	±22.2%	100.0%	±0.0%
kWh Factors (Precisions at 90% confidence)						
Connected kWh RR	60.5%	±22.5%	53.1%	±28.9%	90.2%	±59.6%
kWh HVAC Interactive Effect	98.9%	±3.3%	97.6%	±6.4%	101.1%	±1.5%
Hours of Use RR	75.1%	±12.0%	66.2%	±21.5%	95.9%	±16.7%
% On Peak kWh	77.5%	±8.3%	79.9%	±6.5%	73.7%	±26.3%
Non-Electric						
Heating HVAC Interaction Effect (MMBtu/kWh)	-0.00022		-0.00023		-0.00017	

3.4.2 Key drivers

Category 4 had an adjusted gross savings of 43%. This low number was driven by the quantity adjustment and a lower HOU. Other minor driver was the technology adjustment of 7%.

3.4.3 Quantity discrepancies

The quantity reduction is being mostly driven by fixtures not found in-service during the time of the evaluation. The number of lamp sales in the tracking data for visited sites is included in along with the number of lamps not found to be installed for various reasons (i.e., in storage, missing, or burnout).

Table 3-12. Quantity discrepancy for category 4 products (RI only, unweighted)

Quantity discrepancy classification	Category 4	% of tracking
Quantity discrepancy *(lamps not installed at time of site visit)*	**107**	**6.8%**
Confirmed as in-storage, to be installed over time	39	2.5%
Missing	68	4.3%
Burned out	0	0%
Tracking sales quantity total (visited sites, n=6)	**1576**	**100%**

3.5 Category 5, G24 findings

This section summarizes the study's findings for category 5: G24s.

3.5.1 Results

Table 3-13 presents the category 5 results with the in-storage[14] adjustment applied to in-storage sites from this study based on previous study (P49) findings. The RR for category 5 was 130.4% with HVAC interaction effects and in-storage factor included. The relative precision for this estimate was ±43.3% at the 90% level of confidence. Note that the gross tracking savings did not include HVAC interactive effects. The error ratio was 0.76, which was higher than the estimated error ratio of 0.60.

The discrepancy in RR was primarily due to a very high Technology and Operation Adjustment factors. It is important to note the lower quantity adjustment factor (-50%). 2 out 6 sampled sites had more than 70% (88% and 57%) of the fixtures not installed (either discarded and/or missing), quantity discrepancy section below shows an overall estimation of Category 5 (i.e. 6 sample points).

Table 3-13. Summary of category 5 energy RR

CAT 5 Savings Parameters	Energy - LED					
	MA+RI (ń= 12)		MA only (ń= 7)		RI Only (ń= 5)	
	kWh	% Gross	kWh	% Gross	kWh	% Gross
Gross savings (Tracking)	5,248,218		3,424,039		1,824,180	
Technology Adjustment	1,823,051	34.70%	1,042,801	30.46%	795,720	43.62%
Quantity Adjustment	-2,300,147	-43.80%	-1,389,294	-40.57%	-922,607	-50.58%
Operational Adjustment	1,872,533	35.70%	973,308	28.43%	925,437	50.73%
HVAC Interactive Adjustment	157,660	3.00%	65,066	1.90%	96,583	5.29%
Adjusted Gross savings	6,801,314	129.60%	4,115,920	120.21%	2,719,313	149.07%
Gross RR	130.40%		120.21%		151.63%	
Relative Precision	±43.3%		0.5498		0.6871	
Confidence Interval	90.00%		90.00%		90.00%	
Error Ratio	0.76		0.78		0.73	

The category 5 ISR is approximately 68% with the in-storage installation adjustment.

Table 3-14 presents the statewide savings factors resulting from this analysis. All relative precisions were calculated at the 90% confidence level for energy and at 80% for demand. The summer on-peak coincidence factor was 84.8%, with a relative precision of ±5.9% at the 80% level of confidence. The on-peak winter coincidence factor was 82.4%, with a relative precision of ±7.5% at the 80% level of confidence. The table also provides savings factors for on-peak summer and winter kW HVAC interactive effects, kWh HVAC interactive effect, HOU RR and percent on-peak kWh.

Table 3-14. Summary of category 5 savings factors

Savings Parameter	Category 5					
	MA+RI (ń= 12)		MA only (ń= 7)		RI Only (ń= 5)	
	Value	RP @ 80% CI	Value	RP @ 80% CI	Value	RP @ 80% CI
ISR (Quantity Adjustment - kW)	67.50%	±22.3%	68.90%	±39.6%	64.80%	±31.4%
Delta Watts (Technology Adjustment - kW)	134.80%	±4.8%	130.50%	±17.6%	143.60%	±17.2%
Connected kW RR	90.90%	±29.0%	89.90%	±50.6%	93.00%	±47.1%
Summer Coincidence Factor						
On Peak Hours	84.80%	±5.9%	85.70%	±4.2%	83.10%	±22.8%
Winter Coincidence Factor						
On Peak Hours	82.40%	±7.5%	83.30%	±5.2%	80.50%	±16.4%
Summer kW HVAC Interactive Effect						
On Peak Hours	115.20%	±1.0%	114.70%	±1.5%	116.20%	±1.2%
Winter kW HVAC Interactive Effect						
On Peak Hours	100.00%	±0.0%	100.00%	±0.0%	100.00%	±0.0%
kWh Factors (Precisions at 90% confidence)						
Connected kWh RR	90.90%	±29.0%	89.90%	±50.6%	93.00%	±47.1%
kWh HVAC Interactive Effect	102.40%	±1.7%	101.60%	±1.0%	103.70%	±4.4%
Hours of Use RR	139.20%	±12.7%	131.60%	±19.7%	154.50%	±21.9%
% On Peak kWh	76.30%	±6.2%	77.70%	±12.6%	74.10%	±3.5%
Non-Electric						
Heating HVAC Interaction Effect (MMBtu/kWh)	-0.00166		-0.00154		-0.00189	

3.5.2 Key drivers

Category 5 had an adjusted gross savings at 130%. The driver for this is that the HOU and the technology adjustment number were both greater than assumed for this category. The low ISR of 68% was driven by numerous reports of product issues, like flickering caused by a ballast incompatibility.

3.5.3 Quantity discrepancies

Category 5 had a significant number of lamps in-storage. Half of the sites visited had product issues, particularly reports of flickering due to ballast compatibility issues with early generation lamps. A majority of the quantity discrepancy bulbs were missing. The number of lamp sales included in the tracking data for visited sites is included in along with the number of lamps not found to be installed for various reasons (i.e., in storage, missing, or burnout).

Table 3-15. Quantity discrepancy for category 5 products (RI only, unweighted)

Quantity discrepancy classification	Category 5	% of tracking
Quantity discrepancy *(lamps not installed at time of site visit)*	**1992**	**59.6%**
Confirmed as in-storage, to be installed over time	303	9.0%
Missing	1132	33.6%
Burned out	557	16.7%
Tracking sales quantity total (visited sites, n=6)	**3344**	**100%**

As shown in Table 1-1, for three LED categories, the RI C&I Upstream Lighting Initiative is delivering substantially lower savings than claimed by National Grid. Site auditors were unable to locate a large portion of the products claimed in tracking, despite extensive efforts to track down products that were not installed at the locations indicated in the tracking information. The onsite teams observed a complex market that may not always lend itself to a one-to-one correspondence between a distributor sale and a specific installation site. Contractors buy product to install at multiple locations and to have on-hand for future work. Franchisees buy product that is first centrally stored and then deployed to multiple locations. Customers may install a majority of the product, but keep the balance in storerooms.

Data collection done for this study showed large and sweeping discrepancies between the initiative tracking data and what was observed onsite, with the tracking data claiming LED lighting that turned out not to be installed where indicated, for a variety of reasons. As National Grid staff are aware and are in the process of addressing, these discrepancies arose in large part due to issues within the upstream lighting QA/QC regimen. They were also related to initial tracking system inadequacies, including an inability to link specific purchases with ongoing customer activity (such as returns, exchanges, etc.). Since being alerted to these issues, National Grid has begun proactively making systematic initiative changes to address them.

The lighting quality was good in the majority of spaces inspected during this study and the customers' feedback was positive.

3.6 Combined Category 3, 4, and 5 findings: retrofit kits, A-lines and decorative, and G24s

This section summarizes combined findings in category 3, 4, and 5: retrofit kids, A-lines and decorative, and G24s.

3.6.1 Results

Table 3-16 presents the combined category 3, 4, and 5 results with the in-storage installation adjustment applied to in-storage sites from this study based on previous study (P49) findings. The realization rate for these 3 categories was 60% with HVAC interaction effects and in-storage factor included. The relative precision for this estimate was ±30.1% at the 90% level of confidence. Note that the gross tracking savings did not include HVAC interactive effects. The error ratio was 1.11, which was higher than the estimated combined error ratio of 0.69.

Table 3-17 presents the savings factors resulting from this analysis. All relative precisions were calculated at the 90% confidence level for energy and at 80% for demand. The summer on-peak coincidence factor was 57%, with a relative precision of ±12% at the 80% level of confidence. The on-peak winter coincidence factor was 58%, with a relative precision of ±6.1% at the 80% level of confidence. The table also provides savings factors for on-peak summer and winter kW HVAC interactive effects, kWh HVAC interactive effect, HOU realization rate and percent on-peak kWh.

Table 3-16. Summary of combined category 3, 4 and 5 energy RR

CAT 345 Savings Parameters	Energy - LED					
	MA+RI (ń= 79)		MA only (ń= 58)		RI Only (ń= 21)	
	kWh	% Gross	kWh	% Gross	kWh	% Gross
Gross savings (Tracking)	88,875,955		62,891,890		25,984,065	
Technology Adjustment	-3,280,994	-3.7%	-5,456,905	-8.7%	4,642,782	17.9%
Quantity Adjustment	-29,479,601	-33.2%	-19,814,754	-31.5%	-10,487,957	-40.4%
Operational Adjustment	-3,037,764	-3.4%	-5,856,503	-9.3%	5,735,458	22.1%
HVAC Interactive Adjustment	28,241	0.0%	-327,089	-0.5%	628,421	2.4%
Adjusted Gross savings	53,105,837	59.8%	31,436,639	50.0%	26,502,768	102.0%
Gross RR	60.1%		50.0%		103.7%	
Relative Precision	±30.1%		±34.0%		±49.0%	
Confidence Interval	90.0%		90.0%		90.0%	
Error Ratio	1.11		1.15		0.85	

Table 3-17. Summary of combined category 3, 4 and 5 savings factors

Savings Parameter	Category 345					
	MA+RI (ń= 79)		MA only (ń= 58)		RI Only (ń= 21)	
	Value	RP @ 80% CI	Value	RP @ 80% CI	Value	RP @ 80% CI
ISR (Quantity Adjustment - kW)	65.6%	±11.7%	65.5%	±18.4%	65.8%	±22.5%
Delta Watts (Technology Adjustment - kW)	96.3%	±11.7%	91.3%	±13.5%	117.9%	±21.7%
Connected kW RR	63.2%	±17.2%	59.8%	±26.3%	77.5%	±33.6%
Summer Coincidence Factor						
On Peak Hours	57.2%	±12.0%	53.6%	±17.4%	68.9%	±26.2%
Winter Coincidence Factor						
On Peak Hours	58.0%	±6.1%	56.0%	±18.4%	64.3%	±24.3%
Summer kW HVAC Interactive Effect						
On Peak Hours	116.2%	±1.7%	117.7%	±2.4%	112.4%	±4.7%
Winter kW HVAC Interactive Effect						
On Peak Hours	89.5%	±9.0%	86.5%	±15.3%	98.3%	±3.1%
kWh Factors (Precisions at 90% confidence)						
Connected kWh RR	63.1%	±17.2%	59.8%	±26.3%	77.5%	±33.6%
kWh HVAC Interactive Effect	100.1%	±2.8%	99.0%	±4.4%	102.4%	±4.1%
Hours of Use RR	94.6%	±11.4%	84.4%	±15.3%	128.5%	±24.3%
% On Peak kWh	78.1%	±3.7%	80.9%	±5.6%	72.1%	±6.8%
Non-Electric						
Heating HVAC Interaction Effect (MMBtu/kWh)	-0.00054		-0.00045		-0.00094	

4 CONCLUSIONS

As shown in Table **1**-**1**, for three LED categories, the RI C&I Upstream Lighting Initiative is delivering substantially lower savings than claimed by National Grid. Site auditors were unable to locate a large portion of the products claimed in tracking, despite extensive efforts to track down products that were not installed at the locations indicated in the tracking information. The onsite teams observed a complex market that may not always lend itself to a one-to-one correspondence between a distributor sale and a specific installation site. Contractors buy product to install at multiple locations and to have on-hand for future work. Franchisees buy product that is first centrally stored and then deployed to multiple locations within RI. Customers may install a majority of the product, but keep the balance in storerooms.

Data collection done for this study showed large and sweeping discrepancies between the initiative tracking data and what was observed onsite, with the tracking data claiming LED lighting that turned out not to be installed where indicated, for a variety of reasons. Some of them in storage, some discarded and others missing.

RI has significantly higher RR when compared with MA. This could be due to (see **Table 4-1**): Specifically, in Category 2

- very low hours of use (HOU) in MA (26% in MA compared to 97% in RI)
- low installation rate (RR of 58% in MA vs 84% in RI) in Table 3-5 and
- low Delta kW (51% in MA vs 102% in RI).

Table 4-1: Comparison of Hours of use (HOU) and delta kW between states

Parameter	Category	MA+RI		MA		RI	
		RR	RP	RR	RP	RR	RP
HOU	1	116.6%	±14.2%	125.4%	±24.8%	101.7%	±18.9%
	2	66.6%	±32.5%	26.4%	±34.3%	96.6%	±3.1%
	3	86.2%	±13.6%	76.7%	±17.6%	128.3%	±31.4%
	4	75.1%	±12.0%	66.2%	±21.5%	95.9%	±16.7%
	5	139.2%	±12.7%	131.6%	±19.7%	154.5%	±21.9%
	345	94.6%	±11.4%	84.4%	±15.3%	128.5%	±24.3%
Delta kW	1	185.4%	±14.7%	168.0%	±9.0%	217.1%	±51.9%
	2	67.1%	±32.4%	51.0%	±43.7%	101.9%	±11.7%
	3	87.6%	±16.4%	89.2%	±18.4%	82.6%	±46.2%
	4	92.9%	±17.2%	82.2%	±16.5%	135.1%	±31.8%
	5	134.8%	±4.8%	130.5%	±17.6%	143.6%	±17.2%
	345	96.3%	±11.7%	91.3%	±13.5%	117.9%	±21.7%

RI has better than expected precisions for category 1 and 2 but worse than expected for categories 3,4 and 5. DNV GL recognizes the variability of RRs between the two states but Table 4-2 below shows that there is an overlap in the RRs based on the upper and lower bounds each category. DNV GL is currently planning a new study to better understand the effects of evaluation by combining programs from two states.

Table 4-2: Energy realization rates' upper and lower bounds by category for RI and MA

CATEGORY	RI		MA	
	Lower Bound	Upper Bound	Lower Bound	Upper Bound
CATEGORY 1	132%	194%	168%	229%
CATEGORY 2	48%	117%	-53%	68%
CATEGORY 3	16%	106%	13%	84%
CATEGORY 4	29%	145%	-4%	73%
CATEGORY 5	83%	220%	65%	175%

4.1 Recommendations

This section presents recommendations from this study. Recommendations are organized by:

- Prospective application of results (PY2019 and beyond)
- Process-related recommendations
- Future research recommendations

4.1.1 Prospective application of results

For prospective application of results (PY2018 and beyond), we recommend that National Grid replace tracking system factors with evaluated system factors, the proposed new energy savings factors are provided in below in Table 4-3 (calculated at MA+RI level). For each product type, multiply each factor in the table to derive the annual savings per unit (kWh) value for that product type.

Table 4-4 provides the proposed new peak demand savings factors including the summer and winter coincidence factors and HVAC interactive effects factors. These can be multiplied by the ISR and kW-saved-per-unit factors from to produce summer and winter peak demand savings.

By applying results in this way, National Grid would apply ISRs from this study until a new study is commissioned to assess ISR changes in 2018, following initiative changes made through end of 2017. At that time, National Grid would only need to replace the ISR factor in Table 4-4.

Table 4-3: Proposed Energy Savings factors (MA+RI)

Product type	Category	ISR	kW Saved per Unit	HOU	HVAC Interactive Effect (kWh)
G24 LED	5	67%	0.0173	5,389	102%
A-line, 40/60w	4	65%	0.0312	2,905	99%
A-line, 75/100w	4	65%	0.0438	2,905	99%
Decoratives	4	65%	0.0196	2,905	99%
LED Retrofit kit, <25W	3	66%	0.0356	3,335	103%
LED Retrofit kit, >25W	3	66%	0.0525	3,335	103%
MR16	3	66%	0.0205	3,335	103%
PAR20	3	66%	0.0261	3,335	103%
PAR30	3	66%	0.0354	3,335	103%
PAR38	3	66%	0.0410	3,335	103%
Stairwell Kit, 2ft w/sensor	2	70%	0.0358	5,831	100%
Stairwell Kit, 4ft w/sensor	2	70%	0.0309	5,831	100%
TLED, 2ft	1	67%	0.0079	4,296	104%
TLED, 4ft	1	83%	0.0158	4,296	104%

Table 4-4. Proposed new peak demand savings factors (MA+RI)

Product type	Category	Summer CF	Winter CF	Summer kW HVAC Interactive Effect	Winter kW HVAC Interactive Effect
G24 LED	5	85%	82%	115%	100%
A-line, 40/60w	4	45%	43%	112%	87%
A-line, 75/100w	4	45%	43%	112%	87%
Decoratives	4	45%	43%	112%	87%
LED Retrofit kit, <25W	3	58%	59%	121%	90%
LED Retrofit kit, >25W	3	58%	59%	121%	90%
MR16	3	58%	59%	121%	90%
PAR20	3	58%	59%	121%	90%
PAR30	3	58%	59%	121%	90%
PAR38	3	58%	59%	121%	90%
Stairwell Kit, 2ft w/sensor	2	66%	68%	112%	100%
Stairwell Kit, 4ft w/sensor	2	66%	68%	112%	100%
TLED, 2ft	1	80%	59%	121%	98%
TLED, 4ft	1	80%	59%	121%	98%

4.1.2 Initiative process recommendations

- In their new address validation process, National Grid's vendor should include a flag for customers that have key account managers (National Grid would need to provide current key account management information to the vendor). This key account management flag could be used by National Grid (the vendor would need to alert National Grid of any customers being entered into the initiative tracking data that also have a key account manager) so that National Grid can compare the purchase details with any other current or planned National Grid initiatives the customer could participate in and direct those customers to the initiative that best fits the customer's needs. This would help close the gap between vendor-driven and key account-driven initiatives in cases where this is warranted.[16]

- National Grid's vendor should record and track any customer follow-up activity relating to initiative products in the new inspection tracking system. Vendors should actively check in with National Grid to confirm any direct contact National Grid has had with a customer and any changes to product sales based on that activity are reflected in the tracking data. This will help ensure that when National Grid is contacted by a customer directly and work with that customer to return or exchange any products received through the initiative, this activity gets tracked and saved, to be retrievable later. National Grid and its vendors should agree on a process for this type of communication.
- Vendors should add data validation to tracking data entries so that returns (negative entries) cannot be entered without linking sales to support the return. Initiative tracking data associated with a site can include a negative sales quantity which is typically from customer lamp returns. A negative sales quantity can also be a correction made to the tracking database if the third-party QC contractor could not find the lamps at the site. In order to more easily verify lamp returns made by customers and to avoid possible keying errors, negative sales entries should be linked to the sale in the tracking database. National Grid's vendor should record their follow-up on QC contractor results and how those results were reflected in their tracking system.

4.2 Considerations

- Consider providing distributors with training related to reporting practices and procedures, and tie reporting and verification to distributors. Many times, the lamps were not found on site or the customer had a quantity discrepancy. It could be due to the updates made after the installation or after the purchase was made, but not altered in the tracking data.
- In their new address validation process, National Grid might consider including a flag indicating whether a customer has been served by another distributor. One location had multiple orders in different business names, it could be due to the size of that location, or multiple account numbers, multiple addresses or different people could have ordered the lamps. National Grid should consider tracking those businesses by a distinct address fields and auto populate based on validation prompts.
- Consider using full distinct names of the business without any acronyms.
- In addition to linking distributor sales entries to account numbers, consider including distinct address fields to be auto-populated based on validation prompts. It's possible that large customers have separate addresses for billing, product delivery, and installation; the product delivery and installation addresses should be entered accurately by the distributor based on customer or contractor provided information[17]. Consider building in validation logic so that distributors don't have to enter the same address information multiple times for small customers/purchases.
- Consider adding a purchaser category field such as contractor, electrician, or end-use customer to help track performance progress by purchaser type. This can also help the QC vendor identify contractor projects to follow up with.

---

[16] The evaluation team understands that the National Grid has had a rule in place that if above a certain threshold of fixtures are purchased they should be referred to an account manager in order to engage with the customer regarding other upsell and cross-sell opportunities.

[17] The DNV GL team assumes that distributors enter account information provided by the customer and the billing address and customer name auto populate. This type of data entry would keep customer name and addresses standardized within the data with data entry quality potentially varying in other fields to be entered by the distributor. Having at least the customer and account number accurate and consistent allows the PAs to efficiently track customer activity relating to the upstream lighting initiative.

4.3 Future research

- Consider further ISR analysis. The initiative conducts quality control inspections for about 10 percent of the sites to make sure that they can verify onsite the lighting quantities and types claimed in the distributor sales reports. Part of the intention of the QC contractor visits is to establish that the installs are legitimate, and if not, provide a window for reconciliation after which, if not installed, the units would be backed out of the tracking data and appear as negative sales entries in the third-party provided data for the year of the install. National Grid could consider supporting further research into the discrepancy between ISR shown by the QC contractor visits and those found in this evaluation. Interviews with the third-party initiative manager could help to explain potential tracking challenges.
- Conduct a process evaluation after initiative changes are complete to assess areas of improvement due to the changes. The last process evaluation of the MA C&I Upstream Lighting Initiative was conducted as part of the 2012 evaluation. The timing for a process evaluation of the initiative within the next 6 to 8 months is good to inform and assess initiative delivery.
- Consider assessing the quality of the initiative data in 2018 following the rollout of initiative changes.
- Consider identifying purchaser thresholds by account number, distributor, purchaser, and/or customer installation address. The initiative uses a threshold to prompt follow-up; having multiple thresholds can help identify the individual to follow-up with.
- Consider exploring the extent to which customer installation addresses and associated installation fields have more than one distributor selling products to that address. It’s expected that this would be a more problematic issue prior to initiative changes since initiative changes will now include an address validation process as well as require more detailed information be entered around the location for where products are being installed.

APPENDIX A 2015 UPSTREAM LIGHTING INITIATIVE LED PRODUCT DESCRIPTIONS

This section describes the LED products included in the MA C&I Upstream Lighting initiative in 2015; additional products were added in 2016 and are not included in Table 4-3.

Table A-1. 2015 Upstream Lighting initiative product type descriptions, LEDs only

Product type name	Introduced into initiative/category updated	Description (type/base/typically replaces)	Image
A-line, 40/60w	January 2015	LED A Lamp, Edison base, Replaces < 60w INC and <15w CFLs A-lamps	
A-line, 75/100w	January 2015	LED A Lamp, Edison base, Replaces >75w INC and >18w CFLs A-lamps	

Product type name	Introduced into initiative/category updated	Description (type/base/typically replaces)	Image
Decorative	April 2012	LED Decorative, Candelabra base, Replaces 10w -60w INC and 3w to 14w CFLs	
G24 LED	July 2015	LED, Pin based, Pin based, Replaces G24 CFLs	
LED Retrofit kit, <25W	April 2013	LED down light, Plug/Hard wired fixture, Replaces INC, HAL, and CFL recessed can lamps	

Product type name	Introduced into initiative/category updated	Description (type/base/typically replaces)	Image
LED Retrofit kit, >25W	April 2013	LED down light, Dimmable, Plug/Hard wired fixture, Replaces INC, HAL, and CFL recessed can lamps	
MR16	October 2011	LED, Pin Based, Replaces HAL and CFL MR16s	
PAR20	October 2011	LED R20, Edison Base, Replaces INC/HAL/CFL PAR 20 lamps	

Product type name	Introduced into initiative/category updated	Description (type/base/typically replaces)	Image
PAR30	October 2011	LED PAR30, Edison socket, Replaces INC/HAL/CFL PAR 30 lamps	
PAR38	October 2011	LED PAR38, Edison socket, Replaces INC/HAL/CFL PAR 38 lamps	
Stairwell Kit w/sensor, 2ft and 4ft	June 2014	Linear bi-level Motion Sensor LED Light, Replaces fluorescent lamps	

Product type name	Introduced into initiative/category updated	Description (type/base/typically replaces)	Image
TLED, 2ft and 4ft	January 2015	LED T8 replacement, Pin based, Replaces 2ft and 4ft fluorescent lamps	

APPENDIX B DATA COLLECTION INSTRUMENT

Area ID	Space Descry.	Detailed Space Descr.	Controls (Occupancy Sensors, Dimmers, etc)	Baseline Lighting Fixtures				Initiative Lighting Fixtures					Logger Installed		
				Qty	Product type	Watts	Descr. (Length, lamps, ballast, etc)	Qty	Prod-uct type	Model No.	Watts	Descr. (Length, lamps, ballast, etc)	Code	Logger ID	Notes
A1	*Office*	*Bldg 1, Flr 2, Office #732*	*OS*	*4*	*T8*		*2L 4' T8/EB HIGH LMN*		*T8-28*	*2F32SH*			*Log1*	*38655*	

**Note: For stairwells with sensors, auditor to record pre/post for lighting and pre/post for sensors.

Functional areas

Major functional spaces with distinct schedules or HVAC systems.

Area ID	Space Description	% of Facility[18]	Lighting Schedule ID(s)	Cooling System ID	Heating System ID
A1		%	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 V H	0 1 2 3 4	0 1 2 3 4
A2		%	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 V H	0 1 2 3 4	0 1 2 3 4
A3		%	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 V H	0 1 2 3 4	0 1 2 3 4
A4		%	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 V H	0 1 2 3 4	0 1 2 3 4
A5		%	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 V H	0 1 2 3 4	0 1 2 3 4
A6		%	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 V H	0 1 2 3 4	0 1 2 3 4
A7		%	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 V H	0 1 2 3 4	0 1 2 3 4
A8		%	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 V H	0 1 2 3 4	0 1 2 3 4
A9		%	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 V H	0 1 2 3 4	0 1 2 3 4
A10		%	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 V H	0 1 2 3 4	0 1 2 3 4
A11		%	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 V H	0 1 2 3 4	0 1 2 3 4
A12		%	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 V H	0 1 2 3 4	0 1 2 3 4

Notes: ____

____

____

____

[18] Estimated fraction of the total square footage of the facility.

Operating schedules

SCH ID	Days[19]	Operating Hours		Operating Season[20]		%Lit[21]
		Start Time	End Time	Start Date	End Date	
L1	ALWAYS ON	0:00	24:00	Jan 1	Dec 31	100%
L2		:	:			%
L3		:	:			%
L4		:	:			%
L5		:	:			%
L6		:	:			%
L7		:	:			%
L8		:	:			%
L9		:	:			%
L10		:	:			%
L11		:	:			%
L12		:	:			%
L13		:	:			%
L14		:	:			%
L15		:	:			%
L16		:	:			%
LV	Vacation/Shutdown	N/A	N/A			%
LH	Holidays	N/A	N/A	Days/year:		%

- ☐ *New Years Day*
- ☐ *MLK Day*
- ☐ *Washington's Birthday*
- ☐ *Good Friday*
- ☐ *Memorial Day*
- ☐ *Independence Day*
- ☐ *Labor Day*
- ☐ *Columbus Day*
- ☐ *Veterans Day*
- ☐ *Thanksgiving Day*
- ☐ *Thanksgiving Friday*
- ☐ *Christmas*
- ☐ *Other*____________________
- ☐ *Other*____________________
- ☐ *Other*____________________

Notes: ____

____

____

[19] Categorize operation as appropriate for this business, e.g. Mon-Fri, Mon-Wed, Sat-Sun, Holidays, etc.
[20] For use when schedules are different by season, month, or another time period.
[21] Estimated diversity fraction of occupied space that is lit under this schedule.

Important questions

Schedule changes since installation?____

____

Seasonal variation in schedules?____

____

Occupancy/production/business variations? ____

____

Monitored month(s) typical? ____

____

Has the quantity of light fixtures/lamps increased or decreased since participating in the initaitive? [If yes, record how many] ____
[If the contact can show the field engineers an area where the pre-existing lighting is installed then collect baseline info (wattage, and if similar room/application qty)].

Part of a major renovation [obtain square footage information]? [Auditor seeking to answer whether renovation or addition is major enough to trigger code]. ____

[If part of a major renovation, auditor to check off all that apply] What other equipment was replaced at the time of the renovation project?

- ☐ Ceiling grid removed
- ☐ Terminal AC units replaced
- ☐ Studs were exposed
- ☐ Anything else? [Auditor to list what, if anything else] ____

  ____

Reason for LED installation (replacing failed or failing equipment)? [Auditor seeking to understand whether there was some type of systemic failure, or incipient failure, of overall lighting systems]. ___________________________

What was the age of the replaced equipment? [This information will help inform measure life moving forward]. ___

____

Interactive cooling systems

ID	Description	Type	Fuel	Efficiency	Qty	Size (tons)	Age (yrs)
C1		☐ Direct Expansion ☐ Chilled Water ☐ Heat Pump - Air / Wtr / Gnd ☐ ___________________________	☐ Electricity ☐ Natural gas ☐ LP gas ☐ ____________	______kW/ton ______EER ______SEER			
Notes:							
C2		☐ Direct Expansion ☐ Chilled Water ☐ Heat Pump - Air / Wtr / Gnd ☐ ___________________________	☐ Electricity ☐ Natural gas ☐ LP gas ☐ ____________	______kW/ton ______EER ______SEER			
Notes:							
C3		☐ Direct Expansion ☐ Chilled Water ☐ Heat Pump - Air / Wtr / Gnd ☐ ___________________________	☐ Electricity ☐ Natural gas ☐ LP gas ☐ ____________	______kW/ton ______EER ______SEER			
Notes:							
C4		☐ Direct Expansion ☐ Chilled Water ☐ Heat Pump - Air / Wtr / Gnd ☐ ___________________________	☐ Electricity ☐ Natural gas ☐ LP gas ☐ ____________	______kW/ton ______EER ______SEER			
Notes:							

Notes: ____

____

____

Interactive heating systems

ID	Description	Type	Fuel	Efficiency	Qty	Size (Btuh)	Age (yrs)
H1		☐ Hydronic ☐ Steam ☐ Direct Fired ☐ Heat Pump - Air / Wtr / Gnd ☐ ___________________________	☐ Electricity ☐ Natural gas ☐ LP gas ☐ #2 / #4 / #6 ☐ ____________	_____% _____COP			
Notes:							
H2		☐ Hydronic ☐ Steam ☐ Direct Fired ☐ Heat Pump - Air / Wtr / Gnd ☐ ___________________________	☐ Electricity ☐ Natural gas ☐ LP gas ☐ #2 / #4 / #6 ☐ ____________	_____% _____COP			
Notes:							
H3		☐ Hydronic ☐ Steam ☐ Direct Fired ☐ Heat Pump - Air / Wtr / Gnd ☐ ___________________________	☐ Electricity ☐ Natural gas ☐ LP gas ☐ #2 / #4 / #6 ☐ ____________	_____% _____COP			
Notes:							
H4		☐ Hydronic ☐ Steam ☐ Direct Fired ☐ Heat Pump - Air / Wtr / Gnd ☐ ___________________________	☐ Electricity ☐ Natural gas ☐ LP gas ☐ #2 / #4 / #6 ☐ ____________	_____% _____COP			
Notes:							

Notes: ____

APPENDIX C SITE LEVEL RESULTS

Category	Stratum	Site	Facility Type	State	Tracking Annual kWh Savings	Tracking Connected kW Savings	Evaluated Annual kWh Savings	Evaluated kWh HVAC Factor	Evaluated Connected kW Savings	Evaluated Summer kW HVAC Factor	Evaluated Winter kW HVAC Factor
1	1	30201	Workshop	MA	580	0.17	0	1.00	0.00	100%	100%
1	1	76011	Retail	MA	871	0.26	703	0.76	0.47	120%	47%
1	2	82831	Office	MA	3,076	0.90	2,460	1.03	1.08	127%	100%
1	2	85511	Parking Garage	MA	4,237	1.24	21,622	1.01	2.45	105%	100%
1	3	88541	Manufacturing Facility	MA	9,983	2.93	14,896	1.05	3.87	115%	100%
1	4	46241	School/University	MA	20,313	5.96	20,070	1.02	3.92	117%	100%
1	4	63241	Manufacturing Facility	MA	24,492	7.18	35,231	1.12	13.77	127%	100%
1	5	48981	Hospital	MA	58,038	17.02	144,658	1.03	30.00	117%	100%
1	5	58351	School/University	MA	80,818	23.70	163,332	1.04	44.56	117%	100%
1	5	126431	Retail	MA	38,305	11.23	183,662	1.04	26.40	127%	100%
2	1	78672	Dining: Family	MA	806	0.09	97	1.00	0.02	100%	100%
2	1	98582	Other	MA	2,418	0.28	-90	1.00	-0.04	127%	100%
2	2	64842	School/ University	MA	33,849	3.86	4,186	1.00	2.26	100%	100%
2	3	22232	Multi-Family	MA	49,585	5.66	11,050	1.00	1.26	100%	100%
2	3	33282	Office	MA	308,667	35.24	9,916	1.00	5.25	100%	100%
3	1	98413	Healthcare-Clinic	MA	1,903	0.49	327	0.68	0.22	127%	20%
3	1	23003	Warehouse	MA	2,696	0.69	0	1.00	0.00	100%	100%
3	1	30013	Retail	MA	2,049	0.53	2,203	1.14	0.82	125%	100%
3	1	110703	Healthcare-Clinic	MA	2,522	0.65	161	1.09	0.08	127%	100%
3	2	81983	School/University	MA	4,747	1.22	455	1.12	0.64	127%	100%
3	2	13	Warehouse	MA	5,464	1.40	0	1.00	0.00	100%	100%
3	2	71803	Dining: Cafeteria/Fast Food	MA	7,109	1.82	11,546	1.03	1.98	127%	100%
3	2	106243	Retail	MA	4,382	1.12	2,874	1.09	0.95	127%	100%
3	2	123303	Office	MA	5,477	1.40	0	1.00	0.00	100%	100%
3	3	26833	Dining: Family	MA	9,756	2.50	1,709	1.00	0.56	100%	100%
3	3	69723	Dining: Bar Lounge/Leisure	MA	9,993	2.56	2,959	1.10	0.56	127%	100%
3	3	98053	Single family	MA	8,799	2.26	4,943	1.02	1.60	130%	100%
3	4	117083	Dining: Bar Lounge/Leisure	MA	23,843	6.11	7,434	1.04	7.00	125%	100%
3	4	100453	Hotel	MA	24,113	6.18	0	1.00	0.52	100%	100%
3	4	103163	Court House	MA	21,908	5.62	35,975	1.03	8.64	126%	100%
3	4	120923	Retail	MA	30,298	7.77	1,655	1.13	0.42	127%	100%
3	5	18923	Hotel	MA	52,999	13.59	47,566	0.84	17.88	127%	50%
3	5	57433	School/University	MA	115,753	29.67	48,327	1.00	18.35	100%	100%
3	5	115743	Retail	MA	34,017	8.72	46,599	1.12	9.50	127%	100%
3	5	130213	School/University	MA	120,307	30.84	73,898	1.06	25.11	116%	100%
4	1	81984	School/	MA	6,279	1.61	455	1.12	0.64	127%	100%
4	1	98054	Single family	MA	1,308	0.34	1,378	1.02	0.49	130%	100%
4	1	123304	Office	MA	1,177	0.30	0	1.00	0.00	100%	100%
4	1	25494	Library	MA	1,047	0.27	1,061	1.04	0.34	127%	100%
4	1	46804	Hospital	MA	4,709	1.21	5,716	1.01	1.16	110%	100%
4	1	94634	Religious Building	MA	657	0.17	224	1.04	0.28	127%	100%
4	1	129474	Other	MA	4,709	1.21	246	1.02	0.14	116%	100%
4	1	78274	Retail	MA	1,570	0.40	1,558	1.04	0.59	117%	100%

4	1	18784	Religious Building	MA	3,675	0.94	274	1.09	0.99	127%	100%
4	2	37304	School/	MA	6,279	1.61	1,611	1.00	1.91	100%	100%
4	2	17414	Dining: Family	MA	8,503	2.18	3,175	1.00	0.74	127%	100%
4	2	113484	Other	MA	12,973	3.33	18	1.00	0.17	100%	100%
4	2	65794	Retail	MA	6,283	1.61	424	1.00	0.13	127%	100%
4	3	27234	Religious Building	MA	39,246	10.06	3,689	1.00	2.79	127%	100%
4	3	53864	School/	MA	27,472	7.04	4,860	1.00	2.91	114%	100%
4	3	132984	Office	MA	26,164	6.71	662	1.00	9.57	100%	100%
4	3	31674	Hospital	MA	45,902	11.77	5,665	1.01	0.78	106%	100%
4	3	115844	Other	MA	30,219	7.75	4,643	1.00	0.96	100%	100%
4	3	62134	Retail	MA	48,453	12.42	5,259	1.09	1.80	127%	100%
4	3	11324	Retail	MA	45,786	11.74	4,326	1.09	1.40	127%	100%
4	4	18924	Hotel	MA	193,236	49.53	233,036	0.82	74.99	127%	47%
4	4	57434	School/ University	MA	92,096	23.61	58,243	1.00	22.49	100%	100%
4	4	204	Hotel	MA	198,140	50.79	44,359	1.00	22.19	127%	100%
4	4	1354	Retail	MA	73,258	18.78	55,615	1.00	12.83	127%	100%
4	4	26324	Hotel	MA	89,094	22.84	30,650	1.00	11.22	127%	20%
4	4	55174	Hotel	MA	186,225	47.74	46,717	1.00	25.47	127%	100%
4	4	61964	Hotel	MA	110,262	28.27	4,668	1.09	4.20	127%	20%
4	4	4124	Hotel	MA	87,910	22.54	20,519	1.11	11.42	127%	20%
4	5	130214	School/	MA	235,473	60.36	266,933	1.06	77.13	116%	100%
4	5	126424	Hotel	MA	261,637	67.07	7,065	1.00	4.93	127%	20%
4	5	94924	Museum	MA	302,714	77.60	55,809	1.00	12.36	100%	100%
5	1	74665	Hospital	MA	1,702	0.44	1,201	1.00	0.28	117%	100%
5	1	98535	Office	MA	15,017	3.85	29,609	1.02	4.80	114%	100%
5	2	22915	School/University	MA	20,424	5.24	47,854	1.00	12.51	117%	100%
5	2	20365	School/	MA	19,122	4.90	4,480	1.00	1.55	117%	100%
5	3	45195	Office	MA	52,461	13.45	55,927	1.00	11.33	102%	100%
5	3	94755	Manufacturing Facility	MA	47,555	12.19	18,730	1.03	2.59	117%	100%
5	3	15945	Hospital	MA	133,305	34.17	6,116	1.01	0.91	114%	100%
1	1	838RI1	Manufacturing Facility	RI	941	0.26	1,636	1.12	0.57	130%	100%
1	2	2189RI1	Manufacturing Facility	RI	12,854	3.49	30,072	1.05	6.15	117%	100%
1	3	1127RI1	Warehouse	RI	57,560	15.62	67,174	1.04	17.74	117%	100%
2	1	321RI2	School	RI	4,836	0.55	0	0.00	0.00	100%	100%
2	1	927RI2	Hotel	RI	5,641	0.64	6,409	1.00	0.73	100%	100%
2	2	1857RI2	Hospital	RI	23,389	2.67	24,906	1.02	2.79	114%	100%
2	2	2248RI2	Parking Garage	RI	23,372	2.67	9,193	1.00	1.05	100%	100%
2	3	1824RI2	Transportation	RI	79,786	9.11	85,603	1.00	10.45	127%	100%
3	1	1104RI3N3O3	Dormitory	RI	782	0.20	299	0.68	0.32	130%	20%
3	1	2518RI3N3O3	Healthcare-Clinic	RI	469	0.12	725	1.00	0.15	100%	100%
3	1	510RI3N3O3	Hotel	RI	2,898	0.75	3,062	1.09	0.58	120%	47%
3	1	802RI3N3O3	Religious Building	RI	313	0.08	1,344	1.00	0.47	100%	100%
3	2	1664RI3N3O3	Hotel	RI	12,678	3.28	13,806	1.06	1.48	117%	100%
3	2	1671RI3N3O3	School/University	RI	6,254	1.62	2,060	1.01	0.56	114%	100%
3	2	2204RI5N3O5	Manufacturing Facility	RI	11,329	2.93	2,068	1.09	0.75	120%	100%
3	3	2229RI3N3O3	Other	RI	46,115	11.92	39,449	1.04	4.66	114%	100%
3	3	271RI3N3O3	Office	RI	46,904	12.12	3,809	1.07	1.50	120%	100%
3	3	323RI5N3O5	School/University	RI	16,994	4.39	2,403	1.06	0.73	117%	100%

4	1	1883RI4	Manufacturing Facility	RI	389	0.10	0	1.00	0.00	100%	100%
4	1	843RI4	Theater	RI	3,893	1.01	0	1.00	0.00	100%	100%
4	2	1660RI4	Performing Arts Theatre	RI	31,392	8.11	32,965	1.00	10.39	100%	100%
4	2	1803RI4	Transportation	RI	15,604	4.03	33,165	1.00	8.38	100%	100%
4	3	1664RI4	Hotel	RI	73,832	19.08	73,111	1.06	8.00	117%	100%
4	3	2067RI4	Hotel	RI	75,763	19.58	26,442	1.08	10.26	120%	100%
5	1	2348RI5N5O5	Police/Fire Station	RI	99	0.03	105	1.00	0.03	100%	100%
5	1	323RI5N5O5	Hospital	RI	14,898	3.85	40,082	1.06	5.47	114%	100%
5	2	1703RI5N5O5	Retail	RI	25,079	6.48	8,923	1.06	0.96	114%	100%
5	2	2391RI5N5O5	School/University	RI	21,702	5.61	13,919	1.00	4.46	100%	20%
5	3	2320RI5N5O5	Healthcare-Clinic	RI	104,287	26.95	53,253	1.01	14.55	114%	100%